underwater engineering

Vol. 1 No. 1 First Issue

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the importance of ASW

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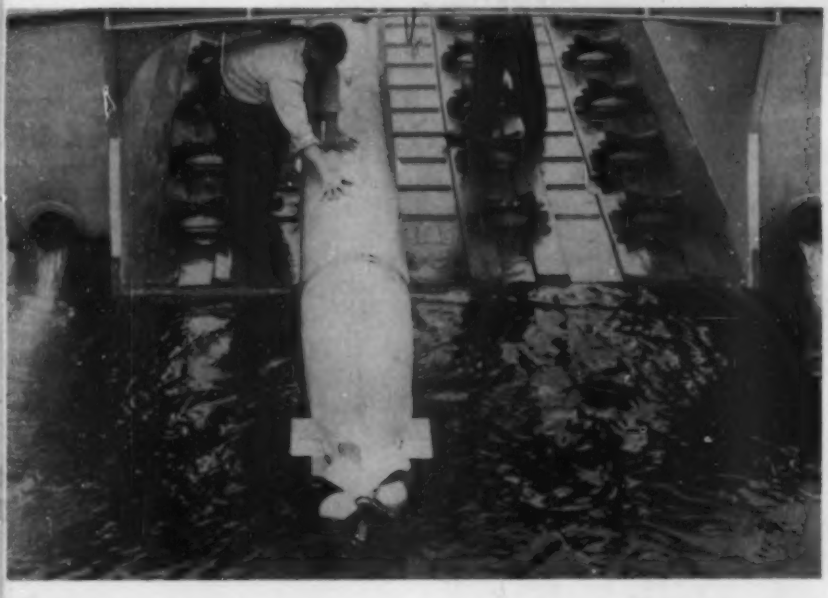
Admiral Arleigh A. Burke
Chief of Naval Operations

ue news trends

ASROC, the Navy's newest and deadliest anti-submarine missile system, has passed shipboard evaluation. It is shown ready for loading into a launcher aboard *USS Norfolk* during test at Key West. Front half is a homing torpedo, boosted by solid propellant rocket. Booster separates in flight and a parachute lowers torpedo into water.

Can we expect a breakthrough in torpedo design? Or is a breakthrough necessary? During its history the torpedo has accounted for more enemy tonnage than any other weapon. But radical new developments may be in the offing. We may one day find the design pictured here to be totally obsolete. After all, it is not radically different from the original prototype designed by Robert Whitehead 90 years ago. As a part of its continuing effort to keep its readers abreast of new developments in anti-submarine warfare and oceanographic science, Underwater Engineering will present a detailed round-up on torpedoes in its next issue. Do not miss it.



The Federal Government will lend support to the nation's leading oceanographers in an international expedition to the Indian Ocean, the White House announced. The scientific exploration will begin late this year and extend through 1964. Navy and National Science Foundation will participate.

Unique motor for the TARTAR surface-to-air guided missile is being produced for the Navy by Aerojet-General under a $2.5 million contract. The normal two-stage booster and sustainer are compressed into one compact unit. Complete weapon is 15 ft long and one ft in diameter.

They call it an "underwater helicopter." Actually, it is a "vertical lift appendage" for Navy's Remote Underwater Manipulator (RUM), an undersea exploring vehicle. Appendage, designed by Hughes Aircraft, would permit RUM to raise or lower itself, move sideways, or hover.

Sonar equipment powered by standard flashlight batteries has been designed by Stromberg-Carlson-San Diego and the Navy's Electronics Lab for use by frogmen to give them "eyes" underwater. The 20-pound sphere is held by the diver, who is equipped with ear phones.

Engineers at Hughes Tool Co.—Aircraft Div. have developed a new high speed over-water vehicle called "Hydrostreak." It is based on a new technological concept—the "water-wall." This is a thin, high-speed sheet of water used to contain a high-pressure "bubble" of air under a vehicle, upon which the vehicle is supported. The concept was invented and developed by HTC—AD as a proprietary item. The experimental craft shown here is 21 ft long, 11 ft wide, and weighs about two tons empty. It was demonstrated in June at the Pentagon Lagoon on the Potomac River in Washington to press representatives and Navy officials.

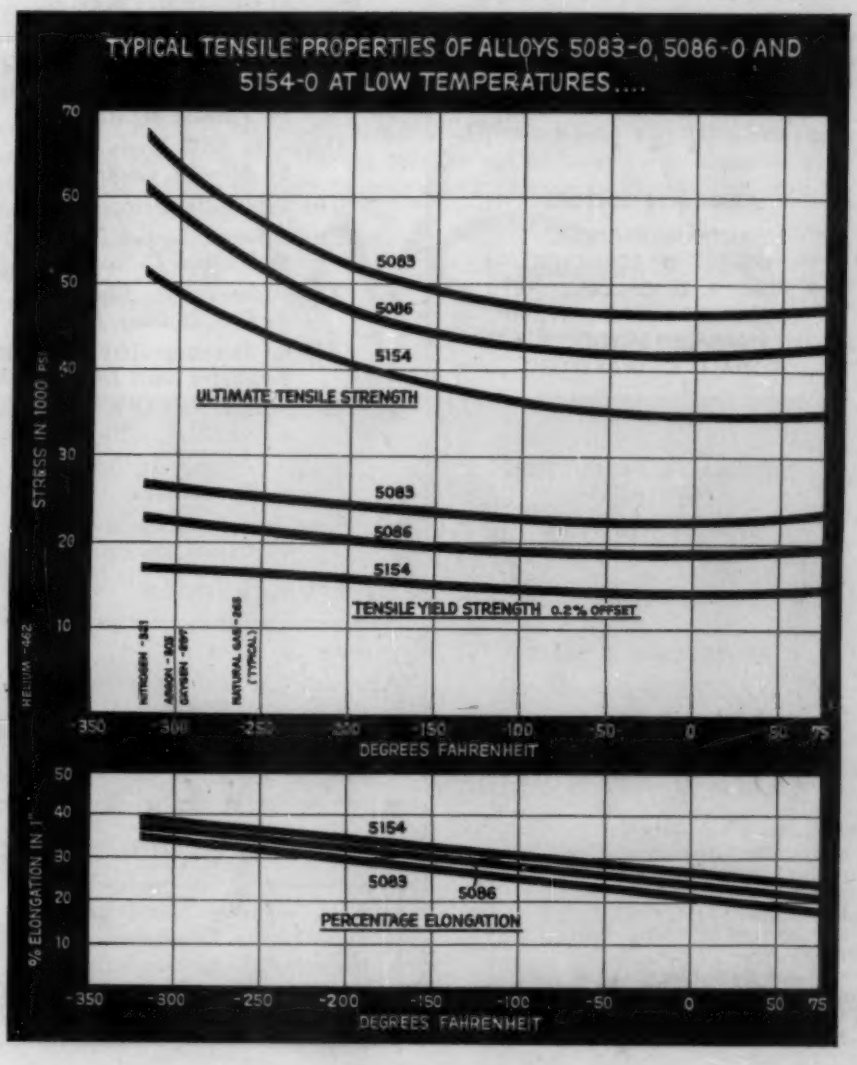
With the increasing need for suitable cryogenics equipment in nuclear submarines, the Navy is taking a longer look at the aluminum industry. Graph, right below, shows typical tensile properties of three aluminum alloys. Another application of aluminum in underwater engineering is in the aluminum submarine. Such a submersible, named the Aluminaut, is being developed by Reynolds Metals Co. It is designed to plumb ocean depths three miles below the surface.

Four new nuclear attack submarines of the *Thresher* class are to be built by Electric Boat Div of General Dynamics Corp. and New York Shipbuilding Corp., under contract awards announced June 14. The boats will have streamlined configuration such as the *Skipjack*.

Full-scale naval battles will be electronically simulated by a $3.6 million nuclear submarine training center to be developed and built for the Navy by the Ordnance Div of Minneapolis-Honeywell Regulator Co. Facility will train crews for POLARIS-armed and other nuclear subs.

Federal Government expenditures for electronics have grown from $500 million in 1950 to $4.3 billion in 1960, and will account for one-third of DoD's spending for "hardware" in 1970, according to RCA estimate.

Boeing Aircraft, in affiliation with J. M. Martinac Shipbuilding, Tacoma, Wash., will build a 115-ft, 110-ton hydrofoil under $2 million contract with Navy. Extensive Navy development of the "Hydroskimmer" is also under way. This is the marine counterpart of the "Ground Effects Machine" which rides on a pressurized air cushion above the earth's surface.



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cover

Advancement in the science of anti-submarine warfare is exemplified by the new Sikorsky HSS-2 twin turbine helicopter. This machine represents the latest rotary-wing mobile sonar carrier of the U.S. Navy. See story on page 60. *Cover design by Jim Fischer, Washington, D. C.*

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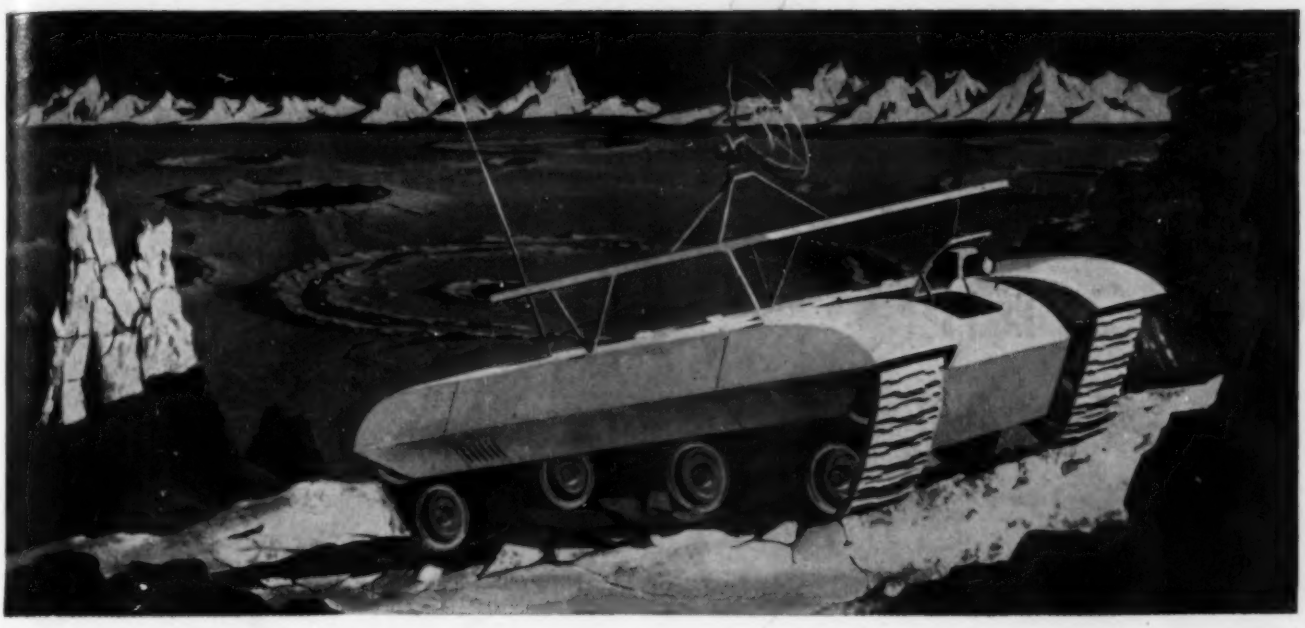

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editorial ★★★★★★★★★★★★★★★★★★★★★★★★★★

By RAdm. W. F. Raborn
Director of Special Projects, U.S. Navy

The conduct of human warfare involves the defense of man and his possessions. To the United States military services a broader mission is given, not only to defend against, but to deter aggression; not only to be dominant, but in dominance to insure the preservation and growth of our free political institutions. Under this mandate, Logic, Logistics, and the Law of Nations point to the sea and the undersea as an environment particularly well suited for the deployment of major weapons systems.

Logic points to the desirability, where practicable, of removing our weapons systems from the close proximity of those we would defend. The large area-effects of modern nuclear arms is such that even concentrated attacks on purely military targets could conceivably result in widespread civilian damage through blast, fire and fall-out. Indeed, the hardening of military targets to withstand massive nuclear onslaughts could perhaps cause an even greater concentration of destructive effort which could work adversely on the areas associated with the defended targets. The logical alternative is to locate a portion of our military systems in the sea, on the surface of the sea, in the air and in the

PINOCCHIO *• so the story goes...*

gave a whale a bad case of heartburn and, thereby, effected his return to the surface. The puppet's idea, however, doesn't approach the ingenuity needed to solve the problems involved in accurately launching *underwater* the Navy's *POLARIS* missile. Like Pinocchio, the *POLARIS* must get topside before it can perform its vital mission, if need be . . .

WTA engineers are assisting Special Projects, Navy Bureau of Weapons in studies and design of essential test and support equipment for the *POLARIS Fleet Ballistic Missile System which is expected to become operational in late 1960.*

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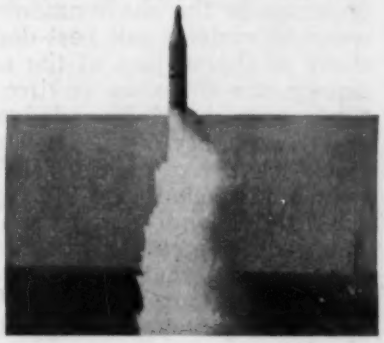

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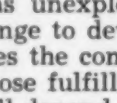
regions of space above the seas. In these environments an abortive enemy attack would most likely fall harmlessly in the ocean or would detonate outside the atmosphere.

As between these two environments, sea and space, logistics points to the exploitation of the sea. The buoyancy of the sea permits mobile cities of several thousand men to exist on its surface and townships of several hundreds to exist beneath it. These communities organized into fighting units have at their disposal military equipments which are measured in ten thousands of tons on the surface and in thousands of tons under the sea. No other environment permits a mobility for systems of such orders of magnitude a mobility sufficient to move beyond the destructive range of a ballistic missile after its course has been irrevocably set. In contrast, the equipments presently feasible for weapons systems in space are measured at best in tons and manned in terms of individuals.

Of equal importance is the impervious character of water with respect to electromagnetic radiation and other forms of energy. A capability is thus provided for hiding large complex systems in a three dimensional space which covers three quarters of the globe. In the solitude of space even the smallest of satellites cannot be hidden assuredly and each follows a trajectory immutably governed by the law of gravity. Logistics indeed points to the sea as the best environment for sustaining the large, complex military bases of modern warfare in a state of continuous readiness, continuous mobility, and continuous security.

It is doubtful if another body of international law is as well established as the Law of the Sea. This legal heritage from ancient Carthage establishes the right of full freedom of the seas to any nation that will use it. Thus our defensive perimeter is extensible to within relatively short distances of almost any potential aggressor. This established right is, however, a double-edged sword and in like manner a potential aggressor may, with legal impunity, hide his systems of destruction along the more than 4000-mile perimeter of our own coasts. Thus our Navy is faced with the dual problem of exploiting the sea for defense of the United States and at the same time denying this environment to any potential aggressor.

Law, logic, and logistics point to the sea and the undersea as the environment in which our major weapons systems can best deploy. Although man's study of the surface of the sea dates back to antiquity, the undersea environment is as yet relatively unexplored. Knowledge of this environment and "supremacy of the sea" are virtually synonomous. A challenge to scientists and engineers is thus presented; a challenge to fully understand a medium as unfriendly, as unexplored, as exciting as outer space; a challenge to develop systems whose sophistication matches the complexities of the sea; a challenge upon whose fulfillment the survival of this country may well depend.



Avco's space experience aids undersea technology. Now, Avco is applying its diversified experience and facilities to many problems of the deep. Avco's Crosley Division is working on projects ranging from arming and fuzing the Navy's Polaris to underwater communications. At Wilmington, Mass., Avco's Research and Advanced Development Division has formed a special undersea technology team. Trained in re-entry technology, it is turning this capability to the problems of anti-submarine warfare and other related underwater studies.

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nautical notes

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By Peer Fossen

The value of the airship has been debated by Navy experts for some 40 years. Today the entire lighter-than-air program is in doubt, and it appears that the airship before long will have flown its last mission for the Navy. Among the blimp's death symptoms are: 1) The number of operating blimp squadrons has been steadily decreased until now only two, one for ASW and one for AEW (aircraft early warning) remain; 2) No new blimp construction is planned; 3) Formal lighter-than-air pilot training has been terminated; and 4) The airship units of the Reserve have been disestablished.

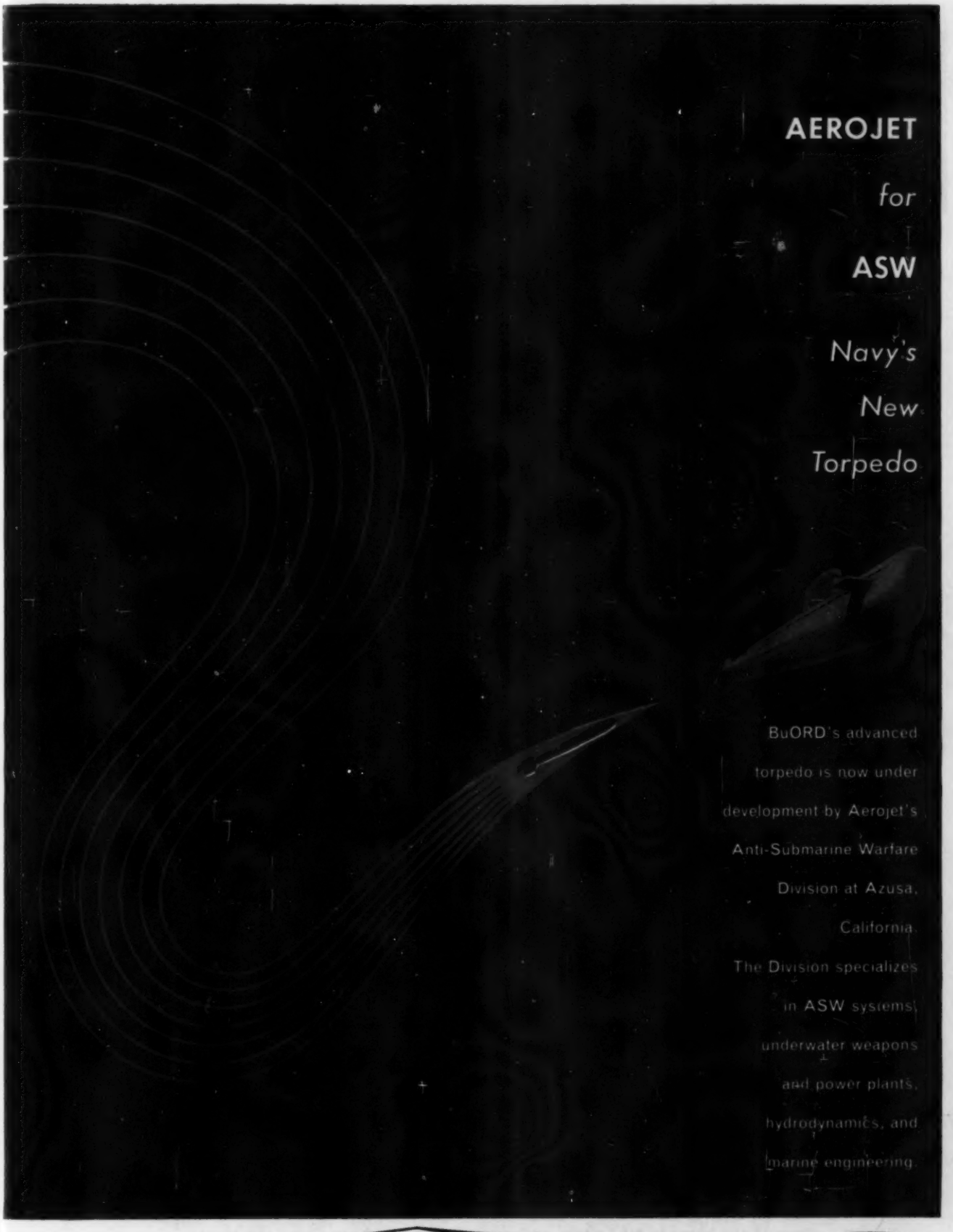
In spite of the fact that Navy's airships appear headed for the budgetary chopping block (and many Navy planners would be happy to see them there) a strong group combining naval and industry experts is fighting a fierce battle to save the lighter-than-air program. And not only to save it, but to expand it. The group, in an effort to counteract the problem of the block obsolescence of the Navy's surface vessels, is pointing to the role made possible by the "peculiar suitability" of lighter-than-air craft to propulsion by nuclear power. The blimp has long been termed a natural for nuclear propulsion. The late Gordon Dean, Chairman of the Atomic Energy Commission, recognized this fact and pointed it out early in the national atomic energy program. However, nuclear airships have never been pursued by the Navy. The reason: "no requirement". Naval planners, examining the current utilization of conventional blimps, have been unable to find sufficient justification for the cost and effort involved in making them atomic propelled. On the basis of the existing applications of airships, their decision is doubtlessly a correct one.

Tactically speaking, A-powered airships have these potential advantages to offer: 1) The ability to operate in an environment separate from that of their submarine targets, gaining thereby certain advantages including greater immunity to counteraction; 2) The ability to mount very complex and heavy sonars—including ones beyond the useful carrying capacity of helicopters—and to dip or tow them without the problem of surface vessel hull interference; 3) The ability to carry and employ submarine detection equipment, specifically MAD (magnetic anomaly detector) gear, normally outside the using capabilities of surface vessels; and 4) The ability to provide exceptional radar covering arising from their stability in flight, low level of vibration and shock, and capability of mounting large antennas internally within their envelopes.

The group fighting to save the airship program says the application of nuclear propulsion is so direct and simplified, and the power requirements so low and uncomplicated that construction of a nuclear blimp could begin now within the present state of the art. The Navy could have a nuclear airship in the air within three to four years. If this time schedule is correct, the nuclear blimp program should interest the Bureau of Ships as well as the Bureau of Naval Weapons, the surface commands of the Fleet as well as the air commands.

J. Gordon Vaeth of Reflectone Electronics, Inc., formerly closely connected with Navy's lighter-than-air program, and author of "Graf Zeppelin" sums up the blimp problem in this manner: "During the late 1930's and early 1940's the Nazis watched the U.S. Navy's internal disagreements over airships with more than passing interest. Hermann Goering volunteered this information after his capture. According to him, Germany's U-boat commanders were highly pleased that blimps were such a matter of dispute since this tended to prevent their effective anti-submarine employment. Now the Soviets, too, are carefully watching what the United States does with its airship capability. They are watching, as did the Germans, with the interest of a major naval power possessing a formidable submarine striking force. If we are going to scrap our lighter-than-air technology, therefore, we must be certain, absolutely certain, that its potential for significant tactical or strategic growth is past."

• • •



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underwater sidelights

By E. E. Halmos, Jr.

"Underwater engineering" is an old story to civil engineers and construction contractors—but their view of it probably requires some definition in relation to the much broader field to be covered by this publication.

To construction men, it means, quite literally, building something under water. They've been doing that almost since the first structure of any kind was built. In fact the first recorded tunnel (for pedestrians) was built by Greek religionists about 600 B.C., under a small river to connect two temples.

In fact, it has been the hard lessons that construction men have learned in their efforts to build things under water that have given rise to much of the knowledge of underwater conditions that exists today. For example, when the Brooklyn Bridge was built early in the 19th century, nobody knew anything about the effects of pressures on a man's body. Many workmen were killed in the crude caissons used to sink the bridge foundations nearly 150 ft below the East river: The bridge's designer, Col. Washington Roebling, himself was rendered a hopeless cripple by a case of the "bends" he contracted while supervising the work.

* * *

Diving bells, caissons—the basic structure of the submarine itself—came out of the efforts and the often tragic lessons learned this way. The use and regulation of air pressure, both to maintain a livable atmosphere and to control the surrounding water came out of it. Oddly—in reverse, these lessons apply just as well to the upper atmosphere, where the problem is not enough pressure, rather than too much.

But many of the materials and methods that have been developed will stand this nation in good stead, now that the vast areas under the oceans have become a matter of prime importance, both for defense and for future commerce. For example, the concreting of the underwater test stand for POLARIS (see p. 70 of this issue) was done by a method (which is patented) especially developed for underwater work: The stone that will become part of the final concrete is placed first, and accurately, then a "slurry" (a thin mix) of water, cement and sand—which is heavier than the surrounding water—is pumped in, to cover the already-placed stone. The result is accurately-controlled concrete, in the right place at the right time.

* * *

Another material is a family of "flash set" cements—mostly containing a high percentage of alumina. Concrete made with this type of cement, for the most part, can't be used "in the dry," because it hardens so fast as to be unmanageable, and sets up so much heat in the process that it will crack. But it is ideal for use under water—and has been used for many years for underwater repairs of dam and bridge structures, for example.

You can add a couple of other techniques too: The knowledge of how to make a pretty sizable "hole in the water"—commonly used in bridge construction— where men can work in the dry. That's done by using sheetpiling to make a watertight box around the area to be worked on, pumping it dry, bracing it properly to withstand outside pressures.

And, where this isn't possible, or circumstances dictate, construction men first developed the "Texas Tower" idea, later taken up enthusiastically by oilmen. This is essentially a barge with legs—legs that can be lowered through the barge to the bottom, and on which the barge can then hoist itself to be clear of the water. These "towers" have been used for temporary, quickly-erected docks; for oil drilling, and even as derrick-bases, mounting extremely heavy lifting equipment to work on construction below.

* * *

The Navy, with its need for docking and repair facilities, has always been a leader in this kind of work. There's another reason too: The Navy usually hasn't much choice as to where it will build its facilities, must build them

usually in already-established naval areas. Some of these are very poor from a construction standpoint—and so the Navy has developed many techniques for building underwater on bad foundations.

(You can't leave the Army's Corps of Engineers out of this, of course. In its historical job of preserving the nation's ports and harbors, it also has contributed much to the knowledge and the techniques of building under water.)

* * *

Failure of a joint U.S.-Canadian proposal for a "six-plus-six" territorial limit on coastal waters left the status of international law on this point exactly where it was before the 88-nation Second Conference on Law of The Sea began in Geneva months ago. In a nutshell, the status is a mess. For instance, the U.S. recognizes a three-mile limit, Mexico nine miles, Iceland and Russia 12 miles, Peru 200 miles. You should note, though, that failure of the proposal (which envisioned a six mile territorial limit for defense, plus an added six miles for fishing rights) wasn't disappointing to Washington. Military men feared that a flat 12-mile limit would close hundreds of sea passages to belligerent vessels in wartime, proving hiding places for enemy submarines in "neutral" waters.

* * *

Chances are still considered about 50-50 that Congress will get around to funding even a part of that 10-year, $650 million program of oceanographic research proposed by the National Science Foundation. Reason is lack of time, rather than lack of interest. Senator Warren Magnuson's (D.-Wash.) Senate Interstate and Foreign Commerce Committee completed hearings on S. 2692, which would authorize the program, and has shown considerable interest in the matter. But with the July political conventions marking a stopping date for Congress, you can figure that matters of this kind will have to be put aside—or given some sort of a lick and promise, in the rush to get out.

* * *

With the success of tests, to date, on POLARIS, it's interesting to see what the Navy is planning for its undersea and ASW activities. Figures recently revealed in Washington include these: Navy would like a fleet of 45 missile carrying submarines, each carrying 16 missiles. But Air Force strategists now have said they think 15 or 20 such vessels would be enough. They say that Navy could install other POLARIS missiles on surface ships.

* * *

The general impact of space operations on manpower requirements of the armed forces has sharpened Congressional interest in a Joint Resolution (SJ. 188) that would establish a Commission on Manpower Needs for Defense in the Space Age. Duties of the commission — if approved — would be to assess manpower requirements and formulate a program for meeting the complex training needs of defense personnel. Implied is an over-riding right to decide whether the armed forces are providing enough manpower and training for adequate defense.

* * *

No matter which service or civilian agency gets to the Moon and other planets first, the Corps of Engineers expects to do the construction, both on Earth and on the Moon. It has started its engineering forces on investigations of what might be needed in the way of construction equipment and materials, machines and the like; as well as climatic and other conditions that will have to be met. One interesting facet of the Corps investigations is that it has decided rubber-tired vehicles won't work on the Moon — a machine with broad, flat metal wheels appears in all of its drawings and plans.

* * *

Although spending by Department of Defense for Research and Development indicates a drop in Fiscal Year 1961, the total is still very large — $3.95 billion, down $300 million from expenditures planned for 1960, but up $400 million from 1959. Most of the cut is reflected in the transfer of the SATURN project to NASA. Of the total for R&D, $1.5 billion will go to missile and related equipment; $318 million to "military astronautics equipment".

Incidentally, the DOD appropriation bill contains these figures for the Navy: $2.1 billion for procurement of aircraft and missiles; $2 billion for shipbuilding and conversion; $1.3 billion for research, development, test and evaluation.

And, on POLARIS, Navy is getting worried about the sudden increase of interest in this missile that's being evidenced by other services and other government agencies. Begins to look as if — now that the missile is near operational status in record time, and represents one of the U.S.' best hopes for attack and defense—everybody wants to get into the act.

navy soundings

By RAdm. P. D. Gallery, USN(Ret.)

The recent report published in London that the British Admiralty was working on a submarine detection device which would make atomic powered submarines as outdated as the old German U-boats has been discounted by both British and U.S. Naval officials. The story originally stated that an underwater "eye" was being developed to detect submerged submarines 1,000 miles away.

* * *

At the House Subcommittee on Appropriations the following ASW terms were defined at the request of Representative Sikes.

JULIE Buoy is a buoy that uses an explosive sound source for echo ranging.

JEZEBEL Buoy is a passive buoy used for fixing the positions of noisy submarines.

RETORC II is a research program for advanced torpedo design.

PCH is an experimental hydrofoil craft designed to accomplish an anti-submarine warfare mission.

Project ARTEMIS is an exploratory development of a long range, deep water fixed anti-submarine detection system.

* * *

Vice Admiral Hayward revealed that there have been great improvements in the reliability of sonobuoys. "We hope with Western Electric and Magnavox we can come through with 95 per cent reliability," he said.

* * *

The Mk 46, a solid propellant-burning torpedo, will be the Fleet's successor to the Mk 44 and is expected to be in operation in the Fleet by 1963.

* * *

Admiral Bennett told the Subcommittee on Appropriations that 534 proposals were received from industry from January, 1958, to 31 December, 1959. Of these, he stated, "we took on 155, there are 214 still pending and most of them are recent receptions."

* * *

The *Thresher* class submarine is the first submarine in which the Navy has made real efforts in cutting down noise. She is sound mounted and has an integrated sonar system. The *Thresher* is due out in April, 1961.

* * *

The SS (N) is designed primarily to destroy enemy submarines but will also be very effective against surface ships. The bow of this submarine is especially designed for optimum performance of the long range sonar which it houses. The Navy holds great hopes for the SS (N) in its anti-submarine warfare program. Long periods of submergence, less likelihood of detection, ability to utilize best operating depths using thermal layer protection are some of the advantages. A total of 29 SS (N) have been approved for this program.

* * *

Task Force ALFA held exercises with the atomic killer submarine *Skipjack* in February. Results are highly classified but some ASW men seemed pleased at some of the results. The ALFA team apparently did a good job holding contact. A Navy officer said, "There isn't much we can say for the record but ALFA did a mighty good job from start to finish." Rear Admiral J. E. Clark has taken over command of Task Force ALFA from Vice Admiral J. S. Thach, who commands the Pacific Anti-Submarine Defense Force.

* * *

Sonar equipment powered by standard flashlight batteries has been designed by Stromberg-Carlson-San Diego and the Navy's Electronics Laboratory for use by frogmen to give them "eyes" underwater. The object locator is a 20-pound sphere, slightly larger than a basketball, and is held by the diver. It is completely transistorized. Ear phones provide the user with audio information on objects detected by the searching sonar beams.

* * *

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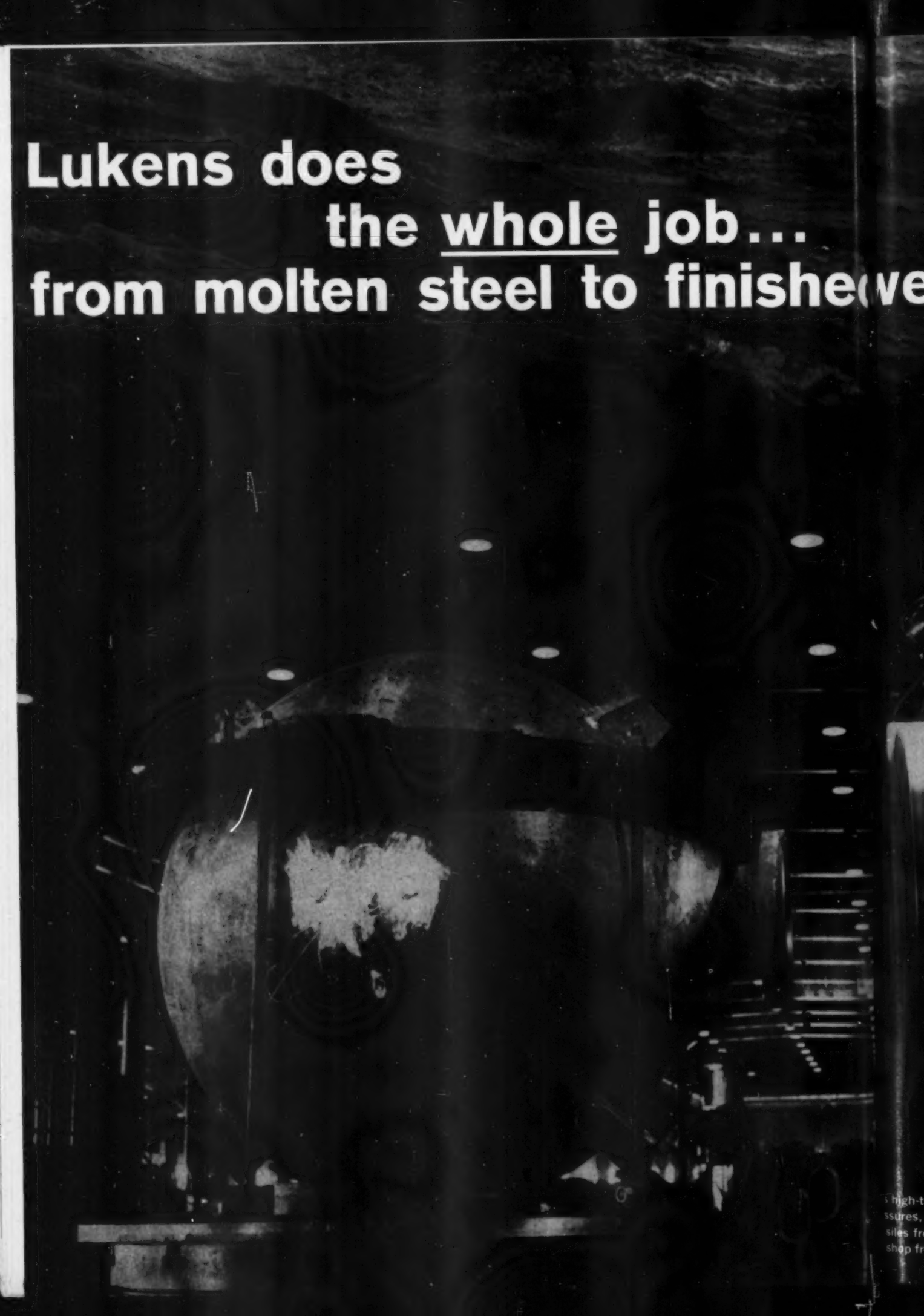

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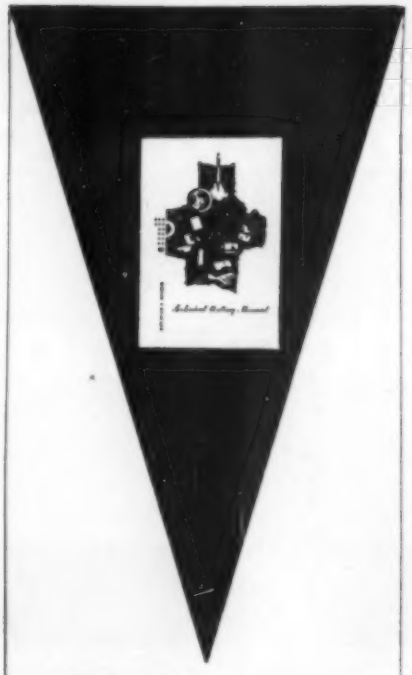

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undercurrents

By William L. Sturdevant, Jr.

Congress is considerably ahead of the Budget Bureau in pushing anti-submarine warfare R&D, nuclear submarines, and the POLARIS program. As a result the money just made available for these vital Navy programs in fiscal year 1961 is $348 million above the figures requested by the Administration.

• • •

Whether all this money is actually spent may rest on the decision of the next President, who will take office in January. The first six months of his term will correspond roughly with the second half of fiscal 1961.

• • •

This Administration has not felt obliged to spend all the money appropriated for various defense purposes, and has withheld funds from some.

• • •

In increasing the Navy appropriation by $294 million over the Administration's budget request to a grand total of $12.109,892, Congress increased ASW R&D funds by $50 million, POLARIS by $241 million, and nuclear sub construction by $57 million. Total dollars available for these purposes in fiscal 1961 are:

ASW research, development, test and evaluation—$230 million

POLARIS program (overall) — $1.346 billion

Nuclear sub construction — $228 million

• • •

The POLARIS increase will mean five fully funded and seven partially funded submarines instead of the three fully funded and nine partially funded as requested by the Department of Defense. In other words, funds are provided for the tenth through the fourteenth subs, advanced procurement of long lead-time components for the fifteenth through the twenty-first, plus missiles and other equipment. When completed, this program will add 336 POLARIS missiles to U.S. strategic forces.

• • •

Four nuclear attack submarines are provided for. This is one more than requested last January and three more than were included in an amended program submitted in April.

• • •

The appropriations act also carries $293 million for a conventionally-powered aircraft carrier as recommended in the President's budget.

The dollar amounts listed earlier do not represent the total ASW market, since funds also are provided for procurement of aircraft, missiles and other ordnance, and building and conversion of other ships.

The total appropriation for the procurement of Navy missiles and aircraft is $2,141,760,000. Missiles provided for are POLARIS, TARTAR, TERRIER, TALOS, SPARROW III, SIDE-WINDER, and BULLPUP, together with essential target drones. The 658 new aircraft funded include additional F4H jets, helicopters in support of Marine Corps vertical envelopment, ASW aircraft and transport aircraft in support of the Marines, along with advanced electronic gear and weapons.

• • •

Procurement of other equipment —generally ordnance items, capital or collateral equipment—is funded with $420,980,000. Majority of the ordnance items are in direct support of ASW. Included are new ASW torpedoes, plus ASROC and ZUNI. In the field of electronics and communications equipment, funds are provided to capitalize on the

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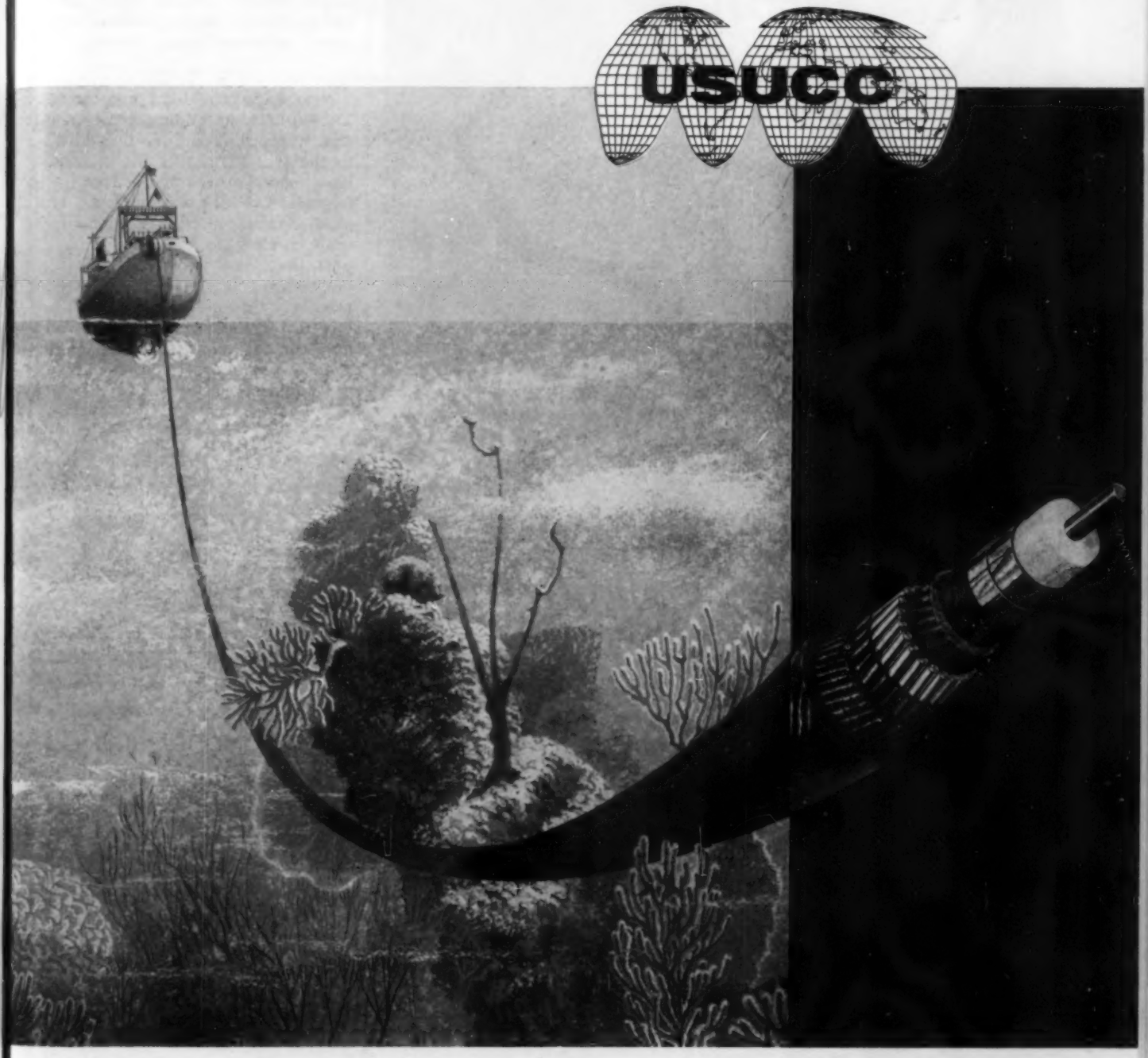

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Navy's successful results in R&D programs, particularly in ASW warfare and air defense, including long-range search radars, new sonar equipment and modernization of the naval communications systems.

* * *

New ships provided for in the $2,316,360,000 shipbuilding and conversion appropriation are, in addition to the five POLARIS and four nuclear subs, three guided missile frigates, two destroyer escorts, two guided missile destroyers, one aircraft carrier, one amphibious transport, dock; one escort research ship, one oceanographic research ship, one auxiliary deep-diving submarine, one fast combat support ship, and one combat store ship. Scheduled for conversion are 14 destroyers and one auxiliary submarine. Twenty new landing craft and two new large harbor tugs are also provide for.

* * *

Exact placement of ASW R&D expenditures apparently is subject to further Navy consideration. Some Congressmen expressed disagreement with the Navy's list of ASW priorities to be covered by the $50 million increase. The Navy was asked to review the relative importance of the items on the list.

* * *

Navy contractors will be interested in this paragraph from the House Appropriations Committee's report accompanying the appropriation bill:

"Timely definitization of letter contracts is still another unsolved procurement problem, especially in the Navy. The average age of letter contracts definitized by the Navy in fiscal year 1959 was 350 days compared to 184 days for the Air Force and 100 days for the Army. As of December 31, 1959, the Navy had 20 letter contracts outstanding for a period in excess of 12 months with some dating back to 1957."

* * *

Also, if Congress has its way, ASW may be integrated under a single-manager system similar to the one working so well for POLARIS. Until this is done, the House Committee reported, "it is doubtful that anti-submarine warfare will attain the goals so urgently required."

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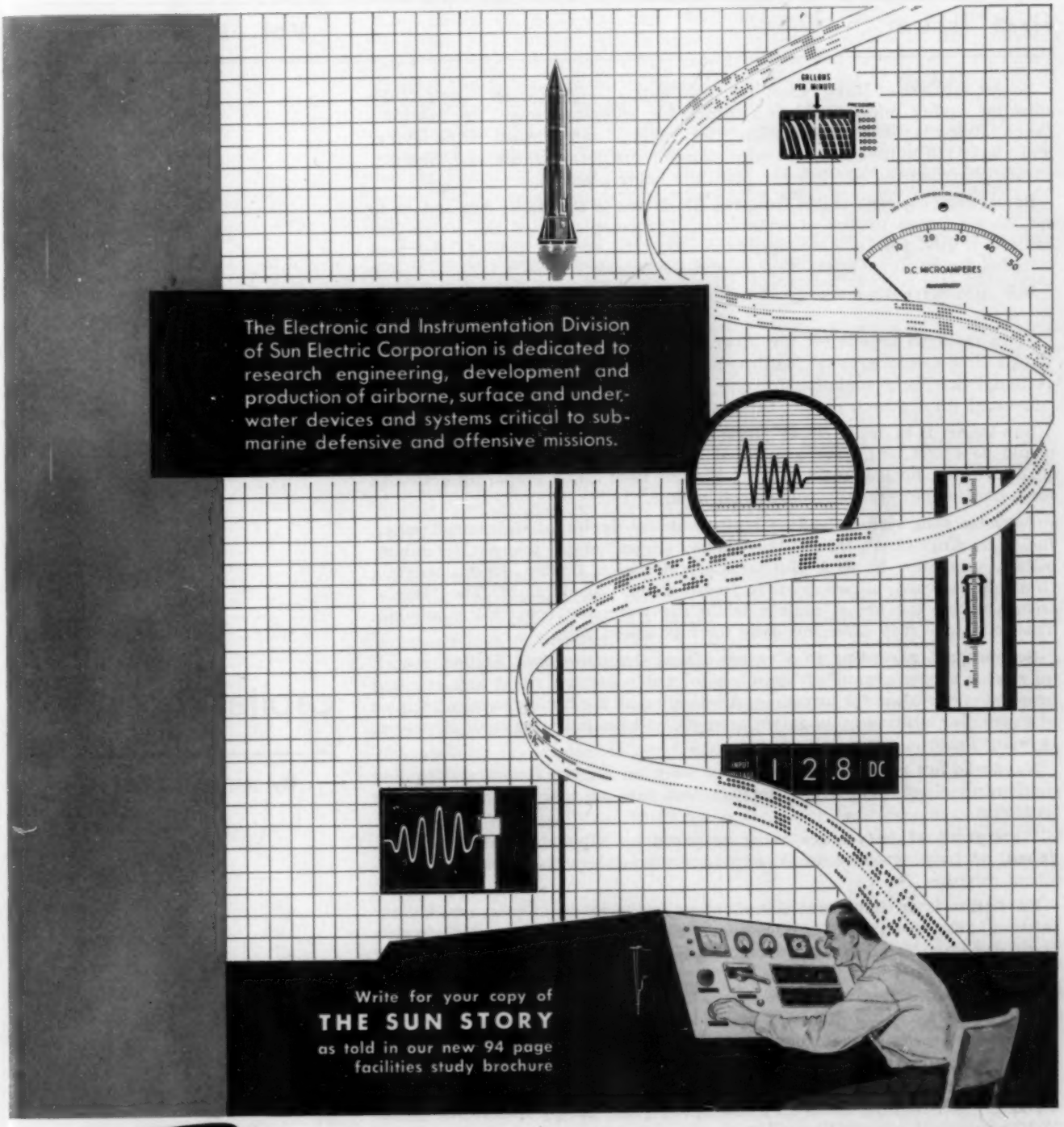

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underwater engineering

first issue Vol. 1, No. 1, 1960

Soviet subs are of three types: over 200 "guppy" — or Z-class— long-range subs for laying mine fields and torpedoing shipping; some 100 medium-range attack subs for blockading, torpedoing, and limited mine-laying; and about 150 limited-range coastal subs for offshore defense and training. In addition, one nuclear sub per month is being planned.

Soviet subs can now travel from the Black Sea to the Baltic Sea and on to the Arctic Ocean by inland waterways. The completion of the Volga-Don canal is a vital cog in allowing inland industrial centers to build and feed subs for Soviet naval operations around the world.

U.S. subs currently under construction number 28. All but two are nuclear-powered.

More research vessels for the Navy. By 1968, some 18 ships are planned. Woods Hole Oceanographic Institution has obtained a $3-million grant from National Science Foundation for one such ship. Naval ship ***Snatch*** is being converted for research use by Scripps Institute of Oceanography.

Sub tanker is in design-study phase at Combustion Engineering. The vessel would be 40,000 tons, have a speed of 50 knots, and be powered by a pressurized-water, nuclear reactor. Also, Electric Boat Co. is preparing drawings for a nuclear powered 20,000-dwt sub tanker.

Porpoise skin studies lead to antiturbulence device of Coleman-Kramer, Inc., Los Angeles. A thin rubber layer, supported by many tiny rubber pillars, was built by U.S. Rubber Co.'s Research Center. Interconnecting channels between pillars contain free-flowing viscous fluid. The "skin's" channels face the vessel surface while the waterside (outside) is smooth. This technique may offer low-drag for high-speed subs.

Sea-animals, according to a recent Naval Ordnance Test Station report, may offer a new avenue of approach toward achieving silent and efficient propulsion operation for torpedoes. Application of the fundamental principles of locomotion utilized by undersea animals, without imitating their structure, is being sought.

Navdocks has compiled an extensive work on marine borers and fouling mechanisms in 56 important harbors and data on 160 other widespread locations.

Waterproof explosives are being prepared by Nippon Kayaku Co., Ltd., Japan, by treating conventional explosive materials with a silicone-organo-silane mixture.

Cavitation is an important complicating factor in developing underwater missiles in the speed range 100-300 knots. Highspeed photos taken at Convair's Hydrodynamic Model Basin indicate that cavitation is a violent process of unstable oscillations.

Hydro-acoustic Test Tank, set up by Hazeltine Corp., Little Neck, N.Y., is 12 ft deep, has a 20-ft diameter, and holds 125 tons of water. Facility checks out sonic responses of sonar buoys and sonar system transducers.

***Fishhook*, POLARIS test vehicle recovery system** is similar to reel used in game fishing. Reel is modified aircraft carrier arresting engine with 1⅛ in. diameter, non-rotating cable on a 200-ft, sea-going gantry tower. The entire *Fishhook* gear is mounted on a 100 ft square Catamaran barge at U.S. Navy San Clements Island sea range. Explosive valves are extensively used in the missile hydro-pneumatic recovery system.

Boron fuels may be used for high-speed underwater missiles or small subs. The fuels could be used in new fuel-cell systems. Fuel and oxidizer are allowed to combine to form water and electron flow. Allis-Chalmers system uses gaseous hydrogen and gaseous oxygen. General Electric also has a hydrogen/oxygen fuel cell system. Prototype cells have produced 800-1,000 watts per cu ft, with an energy to weight ratio of over 100 watt-hours per

capital report

By Alfred J. Zaehringer

pound. At one volt, the specific fuel consumption of hydrogen is around 0.08 pounds per kilowatt hour. A standard gas storage bottle (four ft long, by nine in. in diameter) holds about one pound of hydrogen which would provide ten kilowatts.

GE figures a complete installation for a submarine would weigh about 148 tons today and would have a volume of 9,600 cu ft. It would use LOX and fuel oil. Ammonia or sodium borohydride fuels could also be used. Some five years hence, the system could be reduced to 114 tons and a volume of 8,200 cu ft. On a weight basis, hydrogen would be the preferred fuel. However, on a volume basis, a heavier but lower performing fuel (like the boron hydrides) might be the best bet. Hydrogen and oxygen are the cleanest systems visualized. The boron fuels (as with the case of the hydrocarbons) may prove to be too "cruddy" for electrolytic cells.

Generation of oxygen by electrolysis without hydrogen production has been accomplished at Naval Research Laboratory with a cadmium alkaline battery and sheet nickel plates. The unit has been proposed as an oxygen source for a nuclear submarine since both water and electrical power are readily available.

Oxygen generator using the nickel-cadmium cell has been under engineering feasibility study. Such a unit can be continuously and safely operated with a vacuum purge between cycles. An automated cycle is presently being planned by Electric Boat Co., Groton, Conn.

Baralyme has been investigated for use in the Momsen lung by Thomas A. Edison, Inc., Stuyvesant Falls, N.Y. Material is a blended compressed-pill mix of barium octohydrate and calcium hydroxide and serves as a carbon dioxide absorbent. Use during escape procedures showed that the material was more effective for longer times with lest dust production than soda lime.

Atomic energy for maritime uses should be investigated from the standpoint of international safeguards by shipbuilders, scientists, and statesmen. A University of Michigan legal study recommends that the International Atomic Energy Agency develop international conventions related to the safety of nuclear ship operation, transport of radioactive materials, and disposal of nuclear wastes at sea.

Submerged VLF reception has been studied by NRL. In particular various loop coupling methods and their usefulness to the Navy were included. The study phase relates to the attainment of the best energy transfer from the collecting loop to the receiver.

Arctic oceanography observations by the Air Force Cambridge Research Center have been published on Fletcher's Ice Island (T-3), and covers the period of 1952-55. Report covers geophysical studies, oceanographic observations, movement of ice in the Arctic Ocean, micropaleontology and lithology of epipelagic and under-ice amphipoba, tritium measurements, and oxygen isotopes in arctic cores.

Underwater TV experiments conducted by the Navy Experimental Diving Unit, Naval Weapons Plant, Washington, D.C. with both natural and artifical illumination during day and night show that in relatively turbid water, the night-time performance is somewhat superior to the possible performance in day-time.

Shallow water wave equation for point source has been given a numerical solution by NavOrd. Several frequencies were evaluated and smooth values were obtained up to 450 cps. Higher frequencies required prohibitive computation times on an IBM 650 computer.

Thick-shell, hollow piezoceramic with radial polarization can be used both as a source and receiver of underwater sound. NRL studies used a sphere, electroded completely on both the inside and outside surfaces as the sound transducer.

Marine microbiology procedures developed by Scripps Institute of Oceanography at La Jolla, Calif. permit the study of microbial activities at hydrostatic pressures up to 2,000 atmospheres. Although some cultures of marine and terrestrial bacteria can grow at pressures as high as 800 atm, prolonged incubation at these pressures is lethal to most organisms. Some deep sea forms, termed barophiles, appear only to reproduce under increased pressure. At increased hydrostatic pressure, protoplasmic synthesis appears to be less inhibited by pressure than is cell-wall formation and cell division. The result is the formation of abnormally large cells, chains of cells, and snake forms.

ASW

electro-acoustic transducer for undersea warfare

By Dr. Leon W. Camp
Director, Department of Applied Research,
Bendix-Pacific Division,
The Bendix Corporation

Transducers may be classified as to purpose, frequency, principle of conversion, bandwidth, etc. Operation at frequencies much above 50 KC is to achieve high resolution at short range, while operation below 10 KC is commonly used to get long ranges with high power output. To mention types in wide use according to principle of power conversion, transducers may be piezoelectric, electrostrictive, magnetostrictive, electromagnetic, reluctance, etc.

Piezoelectric and electrostrictive transducers consist of discs, bars, and cylinders, whose dimensions change with the change of an imposed electric field. Magnetostrictive transducers are of somewhat similar shapes whose dimensions change when an imposed magnetic field changes. Used as broadband hydrophones, these transducers may be small compared with the wavelength of sound in the active material, but when used as resonant systems for efficient power conversion, some dimension of the transducer must exceed a quarter wave in length. For example, at 1000 cycles, a resonant magnetostrictive cylinder will be about 15 feet in circumference. This requirement results from the fact that the cylinder develops sound by vibrating in its fundamental radial mode. Since the power handling capacity of these materials per pound is inversely proportional to the frequency of operation, there is a lower limit to the frequency at which these are practical.

Electromagnetic and variable reluctance transducers have an advantage in being lumped parameter systems. That is, mass may be considered concentrated at a point and the spring may be massless. This makes a simple loaded spring system, allowing great flexibility in size and weight. Therefore, it may become necessary in the very low frequencies to develop projectors of these types. The variable reluctance transducer is activated by the interaction between moving iron mechanisms and the magnetic field. Electromagnetic transducers are ac-

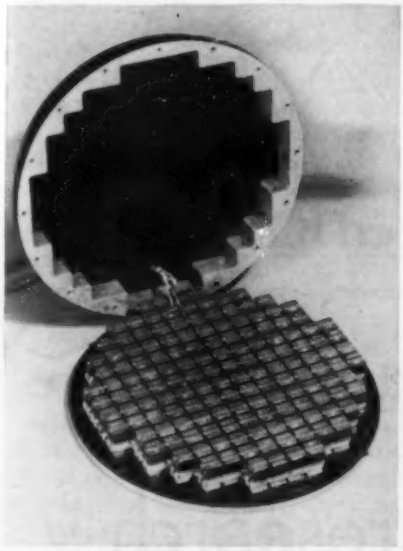
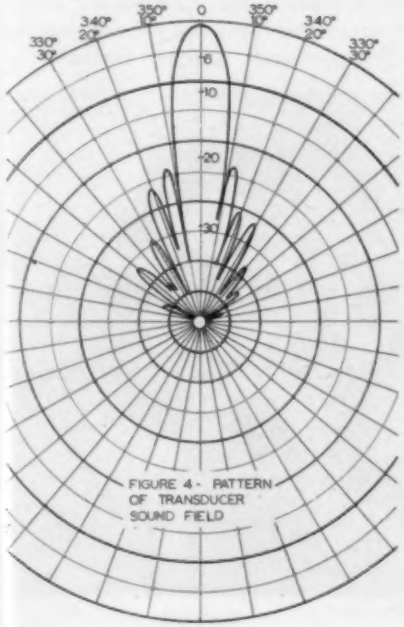


Figure 1. Transducer using magneto-striction elements

tivated by the interaction between a current carrying conductor and a magnetic field.

A rough problem for the systems engineers who are not transducer specialists, is that of finding up-to-date information on the construction and performance of underwater transducers. There are a number of good references for the study of performance characteristics which are common to all types of electro-acoustic conversion systems. The engineers with a good understanding of the equivalent electrical circuit clarifying the impedance behavior as a function of load and frequency has solved most of his problems as far as use is concerned. In addition, he should know how the geometry of a transducer — and this is independent of the conversation mechanism — is related to the geometry of the sound field.



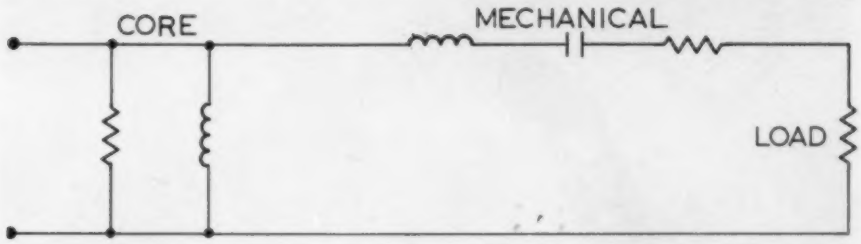


FIGURE 2.

EQUIVALENT CIRCUIT OF A MAGNETOSTRICTIVE TRANSDUCER.

To illustrate these features, Figure 1 shows the inside workings of a 50 KC magnetostrictive transducer. The components shown are longitudinal magnetostrictive vibrators which drive through a rubber diaphragm. Figure 2 is the equivalent circuit for a magnetostrictive transducer, and Figure 3 is the corresponding input impedance locus with frequency as the parameter. Figure 4 is a polar plot of the sound pressure developed in the medium by the transducer of Figure 1. The entire pressure pattern could be fairly well described by a surface generated by rotating this curve about the zero axis. To those not acquainted with these measurement techniques, the plot is normalized to unity on the zero axis and the length of the polar coordinate at any other angle gives a comparative value of the sound pressure at a fixed distance at that angle. This transducer is a plane array having a diameter of about 7 wavelengths as measured in the medium. As can be seen from the pattern, its energy is concentrated into a narrow beam. As with an aperture transmitting light, sound radiator gets larger as measured in wavelengths of sound in the medium.

References: *"Electroacoustics," Hunt—Wiley; "Acoustics," Beranek —McGraw Hill; "Sonics," Hunter & Bolt — Wiley; Magnetostriction Transducers, Vol. 13; NRDC Summary Report—Division 6.*

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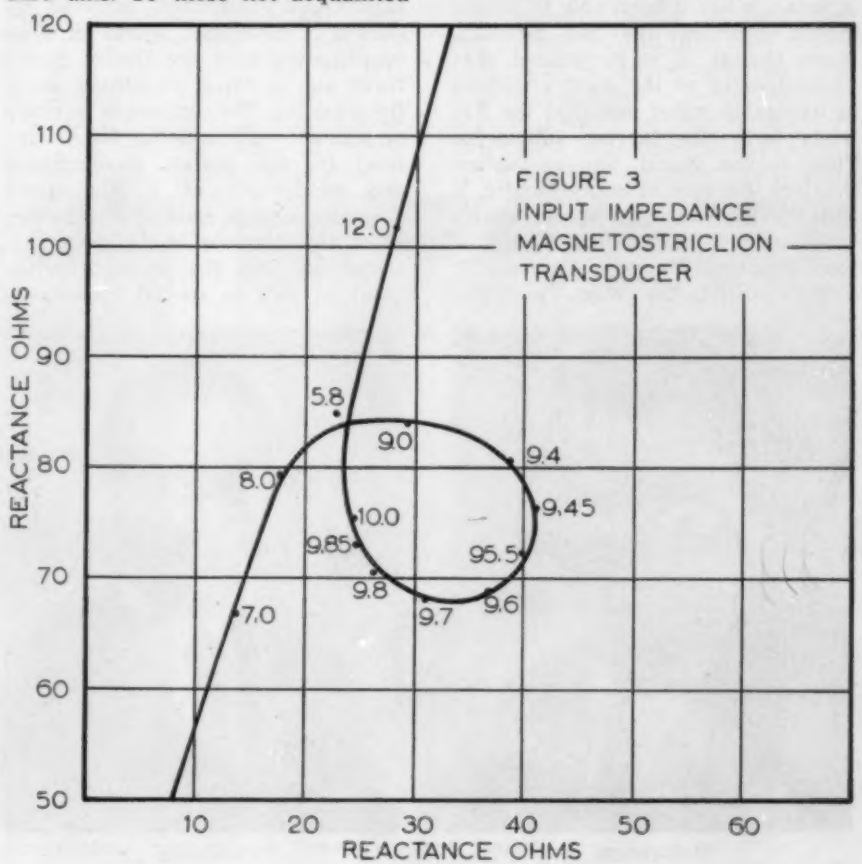
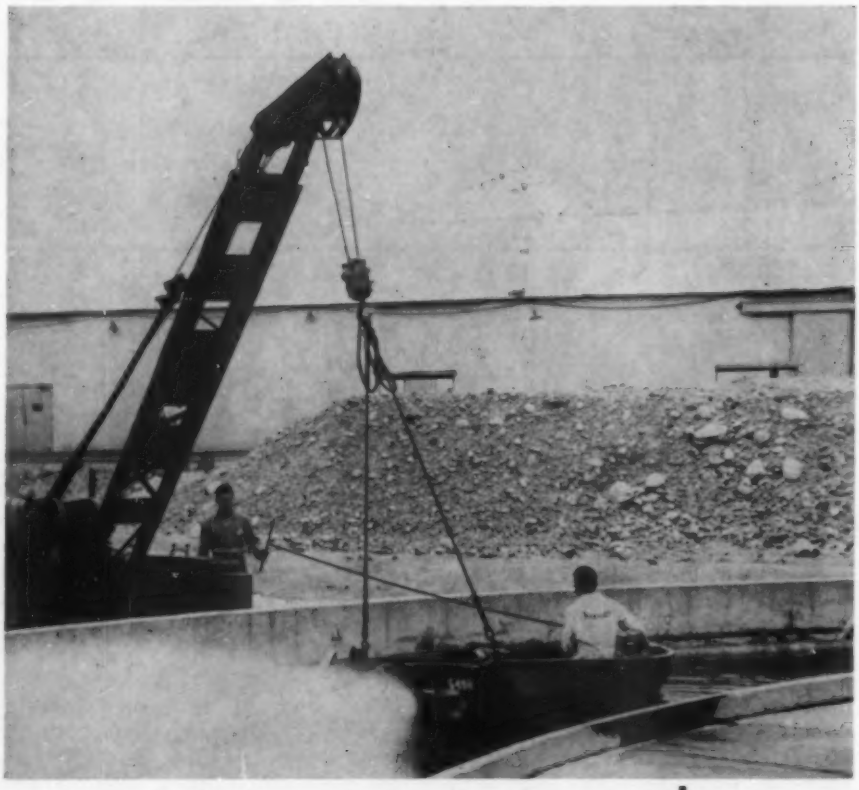


FIGURE 3
INPUT IMPEDANCE
MAGNETOSTRICLION
TRANSDUCER



ASW and undersea research at aerojet-general corporation

AZUSA — Anti-Submarine warfare, for all its recognized importance, does not have the aura of glamour associated with space programs nor has it been able to arouse public opinion like the Sputnik. Even though it is recognized that three-fourths of the earth's surface is navigable water and that the Soviets have the largest submarine fleet in the world, anti-submarine warfare, because of many factors, is still viewed much like Mark Twain's often quoted maxim on the state of the weather. However, when UE editors visited the West Coast recently, they found that this axiom is not true at Aerojet-General Corporation.

Aerojet's Anti-Submarine Warfare (ASW) Division, directed by Calvin A. Gongwer, works in close coordination with the United States Navy and is doing something about the situation. The division is working on a multi-million dollar Navy contract for the design, development and production of a high-speed ASW torpedo of radical design. Besides the torpedo itself, handling, launching, and fire control equipment as well as special component parts are also being devised for this complete torpedo weapon system. This work is under the management of George M. McRoberts.

The division is investigating and working in the entire spectrum of ASW and its allied fields. Its staff is interested in all types of undersea weapon systems including rockets, torpedoes, and other ordnance launched from submarines, aircraft, or special platforms. Liquid and solid propellant propulsion systems, high-speed submerged bodies, towed underwater vehicles, mine sweeping devices, and applied research in

McRoberts

Gongwer

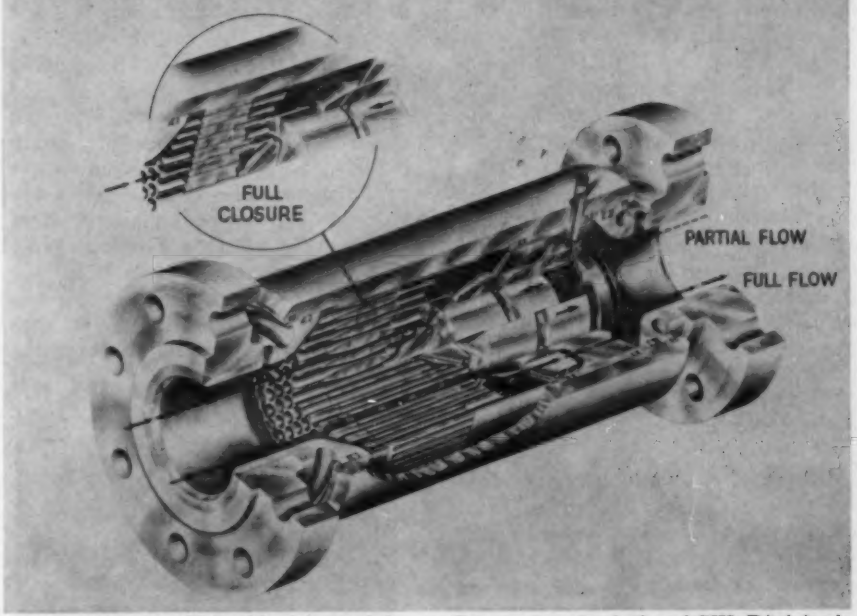
Walcott

wave and sound phenomena are some of the programs under surveillance.

Dr. Fred J. Walcott, Chief Engineer of the Research and Development Department, and his staff have in the hardware stages such developments as the *Silent Valve*, *Hydroduct*, *Hydrocket*, *MiniSub*, and swimmer propulsion units. The throttling *Silent Valve* virtually eliminates aeration, cavitation, vibration, and the resultant noise associated with these physical phenomena. It is adaptable for both shipboard and shore installations. The *Hydroduct* is a water ram-jet power plant which uses sea water as a source of steam and can be employed in underwater weapons. The special, non-gassing, solid propellant Alclo is used so that the water jet is 100 per cent condensable. Very high underwater speeds have been attained with this device.

The *Hydrocket* is a water jet propulsion system used to power surface craft and eventually hydro-foil boats at high speeds. The system uses a conventional marine engine as its source of power. The *MiniSub* is a two-man, free-flooding submarine that could be employed by frogmen or operated as a battery powered, remote-controlled drone. The swimmer propulsion units come in a variety of sizes, ranging from a one man bicycle-like unit to an aqua sled capable of carrying several hundred pounds of military explosives. The division also recently completed investigating the utility and feasibility of an underwater cargo vessel on a working study contract with the U.S. Maritime Administration, U.S. Department of Commerce.

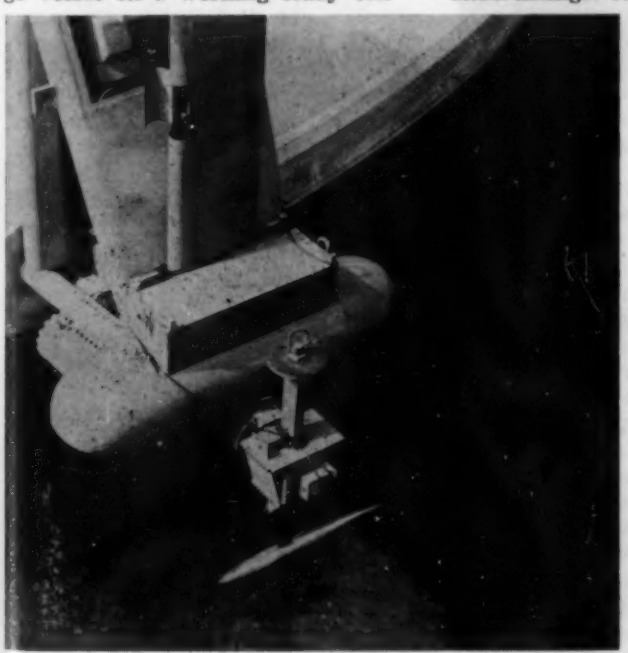
AEROJET-GENERAL'S SILENT VALVE



The ASW Division in Azusa, California is working closely with other Aerojet divisions in exploring every aspect of this liquid medium. Aerojet's Atlantic Division located in Frederick, Maryland and managed by Dr. John V. Atanasoff, is actively engaged in the field of underwater acoustic communications, detection, and identification. Dr. Atanasoff is a recognized authority in acoustics, theoretical and experimental physics, and engineering.

These are some of Aerojet's present programs, but what of future undertakings? According to Arlie G. Capps, head of the ASW Division's "blue water" planning and coordination for future projects, the problem is looked at from both a long and short range view point. The resulting programs and goals are selected by Aerojet's management after a thorough evaluation of the Navy's needs and the company's ability to perform in those areas.

In the long range or beyond the existing state-of-the-art, investigations consist mostly of basic research studies. In this blue water field, Aerojet is looking toward the engineering needs of conceptual systems that will give sizeable orders of magnitude improvements over existing hardware systems. These ideas



Advanced hydrodynamics research at Aerojet's Azusa facility

are generally five to ten years away and involve inventions or significant state-of-the-art achievements. Aerojet expects its largest contributions to ASW within the next five years to be in the realm of high-speed underwater weapon systems, such as advanced torpedoes, rockets, and perhaps small aircraft-like fighter and drone submarines.

In the short range or here and now, Aerojet is looking for quicker and different applications of already existing state-of-the-art knowledge; things that could be done generally through a hardware stage in less than two years. These short range programs are forecast for periods of six months to one year with revisions made to this prediction every month.

However, it should be noted that Aerojet has never taken a short range point of view towards the undersea menace. The company recognized the necessity for serious work in this field in 1944, just two years after the company was formed, and research work was started on advanced underwater propulsion systems on a departmental level. This was 14 years before the *Nautilus* transit under the Arctic ice pack, the successful tests of the POLARIS, and fleet ballistic missile submarine launchings awakened others to the need for stronger undersea defenses. By 1951, this department, its staff, and projects had grown to divisional proportions and the Underwater Engine Division was formed. In early 1958, the group was designated the Anti-Submarine Warfare Division, a title more compatible with its research, design and development programs. Gongwer has been head of this organization since its beginning.

The division's engineers and technicians have years of practical field experience in anti-submarine operations. Many of these men are Navy veterans who have served aboard submarines, aircraft, and surface vessels and have participated in hunter-killer ASW exercises as well as the real thing during World War II. Others have worked in government, university, and industrial research laboratories studying underwater problems and related phenomena. A large number of these 310 scientists and engineers and technicians hold majors in physics, math, hydrodynamics, naval architecture, mechanical, marine, electronic, and chemical engineering as well as naval science.

To assist these men in their work, Aerojet has special facilities for conducting hydrodynamic tests, tests of underwater propulsion devices, studies of wave motion and underwater phenomena, and range testing of prototype models. Primary tests are conducted in the scientifically instrumented large water-filled ring channel with a high-speed (100 knots) rotating boom. This 100-foot boom is capable of testing both model and prototype underwater propulsion devices and is extremely valuable for hydrodynamic studies. Underwater ballistic problems may also be investigated here. The ring channel is augmented by a steam-water tunnel for small scale studies of flow; and steam condensation problems to a simulated depth of 1500 ft.

Aerojet test engineer climbing aboard Minisub.

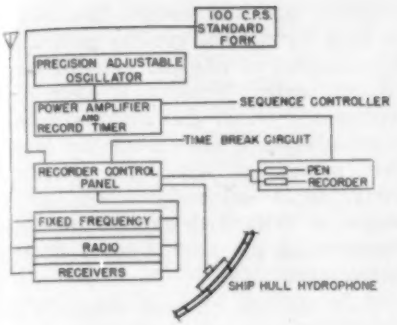
The Division also has under its cognizance a 17,520 square ft model basin where studies of wave motion and underwater phenomena are investigated. For range testing of prototype models, an underwater cableway and large fresh water lake are available at the nearby Naval Ordnance Test Station installation, Morris Dam. Accurate speed, noise and wake measurements can be made at this isolated yet convenient location.

What are some of the problems that loom on the horizon? There are many of these but, in general, Aerojet believes that prospects look bright. Underwater engineering problems are in most respects similar to those in air and space, but difficulties are compounded in view of the liquid medium in which issues of communications, low drag vehicles, high pressure, etc., must be solved. The most critical technical problem areas are in high efficiency, lightweight propulsion units which are capable of operating against back pressures varying from near the surface to several thousand feet, and in guidance systems which do not throw away the information at a time when the weapon takes over from the fire control system. For instance, midcourse guidance for torpedoes would be a major breakthrough to the technical problem of long range acquisition for higher guidance capability.

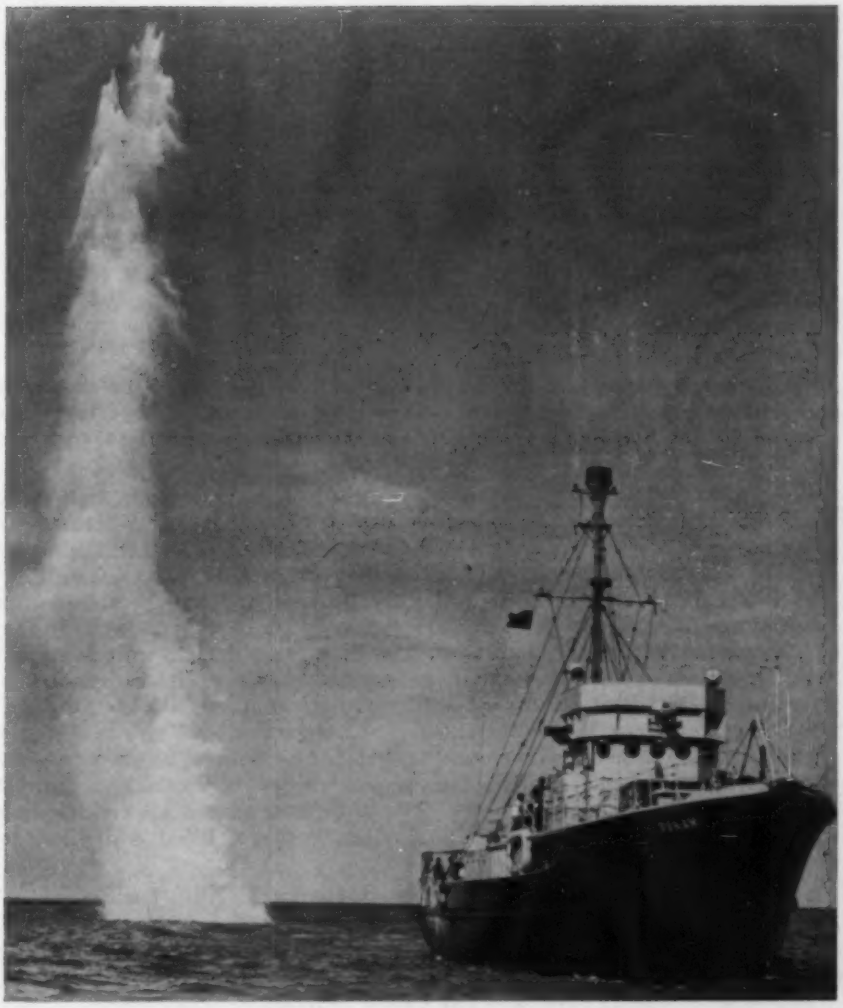
Progress in underwater systems will probably be slow because of two limiting factors — technical and financial. In the technical area, detection problems are far from a satisfactory solution in terms of the overall requirements for a high degree of effectiveness. Increasing complexity of detection systems can be expected because there seems to be no simple solution within the current state-of-the-art. Aerojet's ASW'ers, however, have subscribed to an interesting philosophy that is worth consideration. This points towards investigating simpler concepts where high reliability and larger forces or number of units can perhaps, under certain conditions at least, give higher return on the dollar investment. An example of this might well be the underwater rocket field.

Another area of concern to Aerojet is in acquiring experienced personnel. This can probably be attributed to the fact that, until recent years, the field of underwater engineering and its related services, such as oceanography, have been neglected and did not offer substantial promise for a rewarding career. Therefore, it has been rather difficult to find well qualified individuals with the education and experience necessary for work in underwater research and development.

The ASW work at Aerojet has the full backing of corporate management and is handled on a par with the company's major missile programs. The Anti-Submarine Warfare Division engineers are aware that solutions to the ASW problems will probably be a slow, laborious process with more heartaches than headlines but the conquest of inner space is more intriguing to them than all the wild, blue yonder above.



SONO-BUOY RECEIVING SYSTEM



the value of seismic recordings

By George M. Pavey, Jr.
Seismic Engineering Company, Dallas, Texas

Underwater seismic explorations of tideland areas in many parts of the world are conducted from a single boat which carries all instrumentation necessary for detecting and recording seismic signals and for electronically surveying the area studied. All exploration is conducted while the ship is navigated on a steady course at a constant speed of seven knots.

Developed and used by Seismic Engineering of Dallas, Texas, the system can be operated in almost any kind of weather with consistent results. Seismic signals from the original reflection to the weakest signal attenuated 100,000 times are picked up by a sensitive detector and recorded on a multichannel oscillograph. The detector—or streamer—is an oil-filled hose containing hundreds of lead-zirconate-titanate ("PZT")* ceramic transducer elements. The hose can be up to 3,000 ft long.

A series of sonobuoys distributed in the prospect area form a surveying network which accurately locates the position of each shot blast.

Depths from three to 100 fathoms are explored at distances up to 150 miles from shore. The ship carrying the gear is equipped to accommodate a crew for at least 10 day at sea.

Streamer — Since exploration is conducted with the boat in motion, the streamer or hose detector must be designed to overcome disturbances other than those created by the shot.

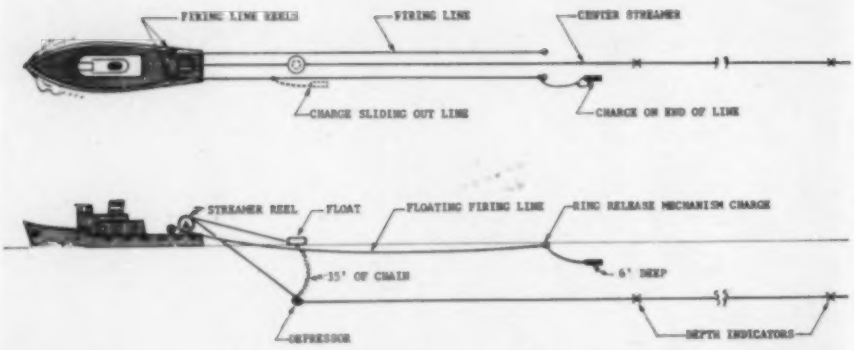
A detection system was developed which is pressure sensitive and which is streamlined enough not to create turbulence when towed through the water. The signal-to-noise ratio is substantially higher than ordinary seismic instruments, such as magneto-striction phones, due to the use of purely pressure sensing "PZT" elements which are free from output due to motion.

Magneto-Striction Phones — In magneto-striction phones operated below resonance, the strain in the nickel sensing element is proportional to pressure. The generated voltage, therefore, is proportional to rate of change of flux and consequently to rate of change of pressure rather than pressure directly. Since frequency affects sensitivity, a compensating filter must be used. This is a distinct disadvantage.

Because of its excessive weight it is doubtful that a magneto-strictive seismic cable could have as many pickups per unit of length as "PZT". Consequently it could not have the same high signal-to-noise ratio.

Diaphragm Phones — Many so-

*Registered Trade Mark, Clevite Corp.



At top, charge sliding out line shows one shot in position to be detonated and another ready to be released. At bottom, streamer is kept level and checked by depth indicators. Ship moves at constant speed of seven knots.

called "pressure" phones are made from diaphragm elements which drive a moving coil in a magnetic field. This type is less effective than the magneto-strictive devices and has the same rate of change of pressure characteristic. The diaphragm must be backed up by a variable air pressure for different depths or it must be extremely stiff to withstand all pressures. In either case the resonant point and sensitivity of the phone are at the mercy of hydrostatic pressure.

Since the diaphragm type units are operated just barely below resonance (instead of eight or nine octaves as in the case of the "PZT" type), the transient response and phase shift of the units may vary widely from unit to unit with only relatively minor differences in mechanical characteristics.

Construction — The streamer developed by Seismic Engineering consists of 100-ft sections of smooth plastic hose with a 1⅞ in. diameter. Each section is filled with oil under pressure and the weight calculated so that its specific gravity is within one quarter of one per cent of that of salt water. Thus, it is neutrally buoyant in water and does not exert a great drag. When towed, the cable will remain at any depth indefinitely. It is generally towed at a depth of 30 ft. Two depth indicators assure that the hose is level within a few feet.

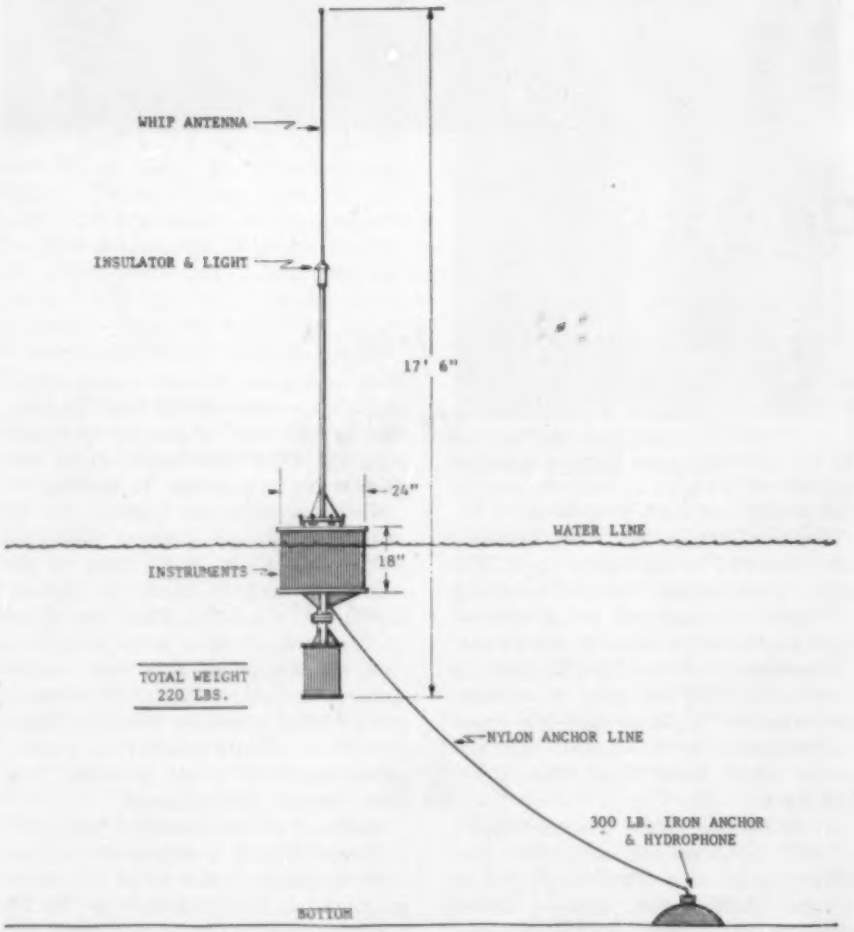
Each section of hose contains 20 "PZT-5" tubular transducer elements mounted four to six ft apart. The 100-ft section of hose detector is continuously sensitive over 80 per cent of its length. Because of the large number of transducer elements used to extend the cable signal pick-up over 100 ft, local disturbances are eliminated. Depending on the specific subsurface problem, 8, 12, 16, or 24 sections of hose are used. Each section provides one channel of information to a multichannel oscillograph.

The tubular ceramic elements, developed by Clevite Electronics Components, are a polycrystalline modified lead-zirconate-titanate ceramic. In this application they are operated below resonance. Useful frequency band for seismic applications is between 30 to 75 cps, but recorder response must be up to 200 cps to obtain full resolution. The transducer elements are not damped and are connected in parallel in each section. The "PZT-5" elements are selected for their shape and generating sensitivity. Sensitivity of the "PZT" is far superior to that of barium titanate, and its piezoelectric constant (g_{33}) is 24.4 as compared to 14.0 for barium titanate.

In applications where 24 hose sections are used, the streamer is 2,700 ft long — 100 ft for each section and a 300-ft dead section in the middle opposite to which the shot is set off. The system will withstand the explosion of a 17-pound shot at 15 ft. The original and reflected pressure shock waves are recorded for a five-sec period. Automatic gain control (AGC) is incorporated in the equipment amplifiers to record all signal traces at equal amplitudes. Signal strength undergoes a 100,000 to 1 attenuation.

Streamline Exterior — Construction of the spread is developed to insure negligible towing noise with respect to normal background at reasonable speeds through the water. Sensitivity is high enough so that instrument noise is well below the earth unrest which is particularly low in the water.

Since the streamer is purely pres-



Sonobuoys are dropped in the prospect area to permit accurate location of each shot. Hydrophone contains "PZT-5" ceramic transducer element.

sure operated, it is non-directional around its axis and requires no gimbals or other means to control the position of its elements. This detection system allows the boat to proceed, during recordings, on a steady course even under heavy wind and sea conditions.

The Surveying System — Since seismic recordings are made while the ship is in constant motion on a steady course, the location of each shot must be pinpointed accurately and rapidly. Each location is plotted using known bench marks on shore and sonobuoys which are dropped in the area surveyed. This system has been used for many years by the U.S. Coast and Geodetic Survey in making soundings for hydrographic charts of offshore areas.

Velocity of sound waves in water is determined by temperature and salinity measurements and by direct measurements involving optically surveyed buoys. When a shot is set off, the initial wave travels to the sonobuoys through both water and earth. The signal created by the sound wave through water is the desired signal since speed of sound through water is more stable and can be determined more accurately than speed of sound through earth. The signal created by the earth wave is filtered out at the sonobuoy. The initial sound pressure wave through water is detected by a single "PZT-5" ceramic transducer element on the anchor of the sonobuoy. The output of the transducer initiates a trigger circuit which actuates a transmitter. The transmitted pulse is picked up at the ship and recorded on a two-channel direct wiring recorder. Since the time for the transmitted signal to reach the ship can be considered instantaneous, the time between the blast and the recorded signal can be considered the length of time it takes for the sound wave to reach the sonobuoy.

On board ship water temperature is measured constantly since a change in tempearture will affect the speed of sound. The recorded sea temperature is transferred to an oscillator which is calibrated in temperature. The output of the oscillator controls the synchronous chart drive in the direct writing recorder. By controlling the speed of the recorder chart paper, time is automatically converted into distance which is to the exact scale of the plotting board. Distance is then rapidly plotted by transferring data with a trammel bar.

Shooting System — Explosives for the seismic shot are played along a line running back from the stern of the ship. The detonator and charge are connected by a ring to the line and permitted to float free back along the trailing line on an expendable float. When the charge reaches a prearranged position on the line the ring engages with a catch. The catch forms one terminal of an electrical firing system. Another line which functions only as a return electrical conductor is parallel to the shot feed-out line. The electrical connection is completed by the salt water between the two lines at the shot. The shot can then be set off from aboard ship at the required time. Subsequent charges fed out along the feed-out line automatically disengage the ring and float from the previous shot. The ring and float are discarded.

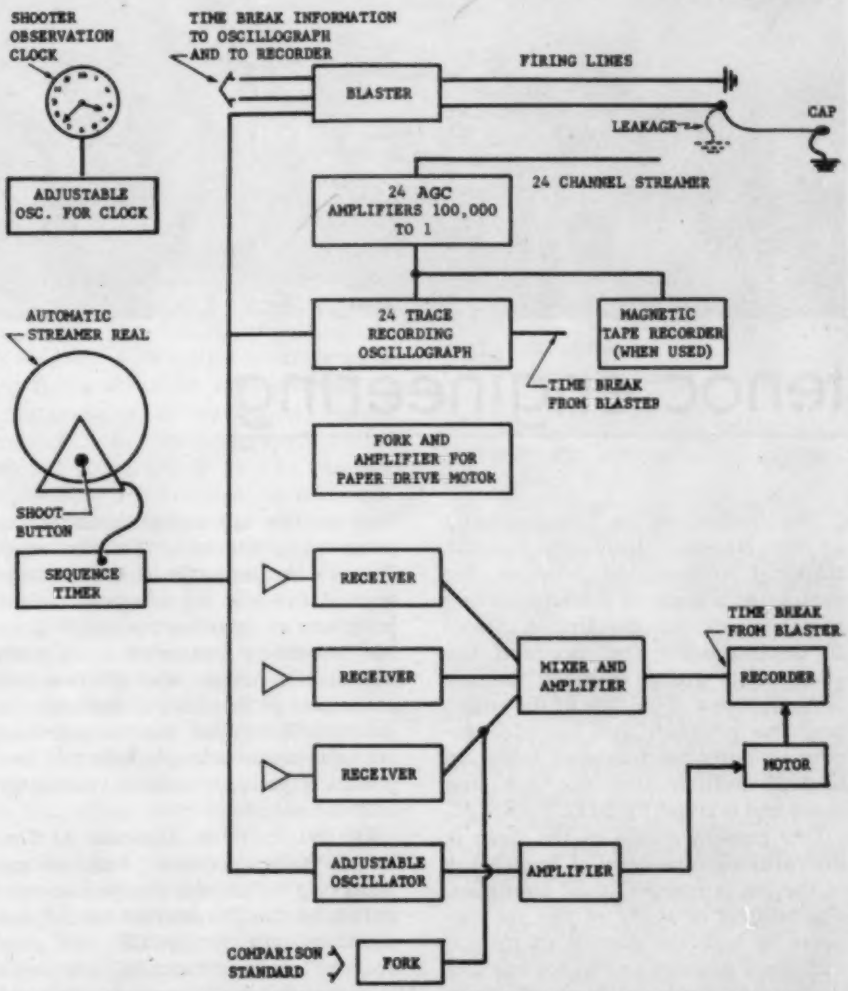
Shots are set off approximately two minutes apart and are detonated at a depth of six ft.

Operation — During shooting operations the course of the ship is controlled by an automatic pilot. A remote course-changing control is located in the plotting room. As shots are plotted any variation from the plotted course can be observed and the exact correction added.

The shooting sequence is all timer controlled. The reel operator closes the firing switch at the proper time to energize the timer. Sequence of events is: a) sonobuoy recorder energized, b) seismic oscillograph recorder energized, c) shot detonated, d) recorders stopped.

Hose Detector Operation—A towing cable leads from the stern of the boat down to the hose detector. At the junction of the towing cable and the detector, a heavy hydrofoil called a depressor is attached; the detector hose streams back from the hydrofoil.

A float on the surface and a chain hold the depressor at a maximum depth of 30 to 35 ft and the streamer trails behind at this depth. When the towing force is released just prior to the shot, the depressor hangs by the chain from the surface float at 30 ft. The whole streamer assembly remains at this depth and slows down by a few knots while the recording is made.



Block diagram of instrumentation for performing seismic explorations.

tenoc engineering

By RAdm. P. D. Gallery, USN(Ret.)

The Committee on Oceanography of the National Research Council, National Academy of Sciences, has completed a study of the engineering requirements for the United States in oceanography for the next ten years. This group includes the top oceanographic scientists of the country. The program and list of engineering equipment needed totals up to $650 million over the next ten years and is titled PROJECT TENOC.

Our present status in the field is low, although the level of knowledge of the sea is meager in all countries. The subject of study of the sea appears to lack the glamor of missile and space projects and hence has had inadequate financial support. Only in the past few years has the public been hearing of the economic possibilities lying on the ocean bottom. The exploits of the *Nautilus, Skate* and *Seawolf* under the polar ice cap have attracted headlines — and interest in the medium through which they are travelling, the ocean depths. POLARIS submarines are familiar to everyone now and the potential of the underseas for national security is gaining prominence daily.

All this adds up to the likelihood that such a program as PROJECT TENOC will be receiving favorable consideration in Congressional circles. Senator Magnuson, Chairman of the Interstate and Foreign Commerce Committee, which holds hearings on the bill recommending this program, declared: "We can meet Russia's challenge for scientific mastery of the seas by adopting such a program as has been suggested — for too many years we have been taking the oceans and the historic principles of freedom of the seas for granted. Today the oceans and their contents assume unprecedented importance to our welfare, economy and security."

Dr. H. F. York, Director of Defense Research and Engineering, testifying before the House Subcommittee of the Committee on Appropriations said, "... in 1961, we propose to make substantial increases in our support of oceanographic and basic interdisciplinary research on materials. In the case of oceanography we believe that, since there is so much unknown about the oceanic environment, it is virtually inevitable that further basic research will yield discoveries of great importance in connection with ASW and other naval problems."

Oceanography has appeal from the peace-time economic view as well as from the military defense angle. Companies in industry that get into this field of science and engineering early will be the giants in the field years from now.

The needs of oceanographic engineering are challenging because it is a new field and new ideas are welcomed. The problem of penetrating the "sound curtain" of the deep has many angles and possibilities.

"Our guiding principle is not to make oceanography more complex or necessarily more expensive, but rather to stimulate the use of new devices which modern technology can make available to the marine sciences," the Committee reported.

What new devices do we have in mind for this ten year program? The details of the equipments, even the methods or principles involved, are still up in the air but inventions or developments are needed as follows:

1) Both permanent and expendable oceanographic instruments for aircraft.

2) Deep submerged vehicles, small and moving, for making and recording measurements at specified depths, on prescribed courses or on the bottom.

3) Equipment for measuring radioactivity in the ocean.

4) Reliable and accurate acoustic measuring devices.

5) Current meters (for measuring ocean currents).

6) Stable platforms on research ships for sensitive and precision devices. (The ship need not be stabilized but certain sections or equipment mounts must be).

7) Density measuring devices.

8) Movie and still cameras and underwater television.

9) Seismic equipment for deep sea investigation.

10) Turbulence measuring instruments.

11) Biological sampling devices—by prosthetic claws, suction scoops, fine nets or other means.

12) Acoustical equipment sensitive enough for biological research.

The above are only a few of the opportunities for industry to take hold of and develop. The future will bring forth more requirements. Development of these ideas could well lead toward solving engineering problems that now prevent us from acquiring and using the economic abundance in the oceans. Ideas for many of the approaches or the solution of these matters will come from individual scientists, hydrographers and oceanographers, men already in the field. However, "Individual workers are encouraged to have as much of the development done industrially as practicable," the committee on oceanography declared.

Cables and winches are equipments of great importance in oceanography, and need improvement. Investigations must be made into the relative merits of steel cables vs. plastic lines and electric wire vs. acoustic telemetering.

Among the specialized survey instruments needed are:

a) Deep winches with electric cables.

b) Precision salino meters.

c) Precision echo sounders.

d) Towed temperature recorders.

e) Deep sea underwater cameras, including still and movie.

f) Magnetometers.

Laboratories ashore must be equipped with:

1) Pressure facilities simulating deep or bottom conditions to aid in study of marine life and chemical processes.

2) Data reduction systems and machine and card storage for data.

3) Analog computers and dynamic models.

Aircraft have not as yet played the important part they can in oceanographic research. They have the obvious advantages of speed and long range, and are actually less costly for many jobs than surface survey vessels. The ability of scientists on planes to see great distances, spot discolored water, currents and eddies, turbulence, flotsam, etc., would be of real value. They could be used for monitoring moored buoys in vast areas. Their use in weather observations is well-known; and they can assist in compiling the large masses of data necessary in the study and prediction of weather. As an aside, we might observe that the advent of jet planes for military and commercial use should make numerous propeller planes available soon. These planes will be obsolete for military and commercial purposes but ideally suited for oceanographic work which does not require jet speed — in fact does not want jet speeds for observation work.

Ski-equipped aircraft will be needed for polar exploration and survey work. This need is pointed up by the successful exercise of our nuclear subs beneath the North Pole areas.

The blimp has advantages for oceanography in that it can hover for prolonged periods when necessary, can use "dunking sonar", and has long endurance on station. (A Navy blimp stayed in the air for ten days and travelled over 10,000 miles in 1957). The stable platform afforded by a blimp is another asset for using scientific instruments.

Conversion of submarines from military to oceanographic uses should come along as our nuclear submarine fleet builds up and conventional submarines become out of date. Removal of military equipment such as torpedoes, tubes, ammunition, etc., will give scientists space for their laboratory ond observation equipment. Observation windows can be installed in the oceanographic subs, along with recording devices and telemetering instruments, both inside and outside the survey submarine, which is not as concerned with speed and resistance to damage as a combat submarine. The long endurance of the conventional submarine at slow speeds submerged will be invaluable. The Committee on Oceanography has plans for converting a submarine into a moored laboratory buoy, which will ride vertically instead of in the normal horizontal position. This idea seems a bit fantastic but is quite feasible if the scientists deem it necessary.

Helicopters can be of use aboard oceanographic vessels for transportation and observation platforms. Their ability to hover and to lower sonars and sampling devices make them ideal for spot observations.

The Committee emphasized the need for a deep-diving submersible, and mentioned 18,000 foot depth as desirable — with ability to lower a bathysphere from the submersible at that depth to a depth of 35,000 feet. This requirement is already out of date since the *Trieste* in January dove to 35,000 feet in the Pacific. These deep diving bathyspheres permit viewing and data taking by human beings — the best data processing and recording system known. Selective sampling, along with some mobility, is another feature of a maneuverable deep vehicle.

The Reynolds Aluminum Company, with the cooperation of the Office of Naval Research, is sponsoring a revolutionary new idea in submarines —the *all aluminum* submarine. Work is already under way on construction of this craft (called PROJECT ALUMINAUT) which is expected to be completed by 1961.

The following characteristics of a new deep-diving submersible are desired in future designs:

1) Space for one pilot and two observers, with 15 cubic feet of space for portable instruments, in addition to space for premanently installed equipment. A diameter of 8 feet seems acceptable.

2) Power for lights and instruments.

3) Endurance of 24 hours with provision for adequate air and dehumidifier.

4) Two observation windows looking forward and down.

5) A speed of four knots for two hours and a range of about 30 miles at 2 knots.

6) Movability about the vertical axis.

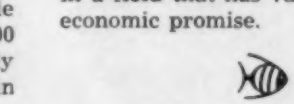
7) Vertical propellor thrust for fine vertical measurements.

8) External arms or claws for picking up samples (suction devices could assist in this).

9) Construction materials that reduce the rates of weight of vehicle to water displaced.

The field of oceanography is wide open in more ways than one. We have only about 500 scientists qualified in oceanography. The military value of oceanographic research has jumped tremendously since World War II with the advent of the nuclear submarine and the POLARIS missile craft. We must learn more about the deep to take advantage of these vessels. And we need more information to plan our defense against the Russian submarine fleet of over 400 subs.

The engineering demands are large and invite original thinking. The program recommended in PROJECT TENOC gives opportunities for many industrial concerns to get in early in a field that has vast military and economic promise.



atomic sub personnel problem

By Patrick McMahon

The most perplexing and complicated manpower problem to confront the U.S. Armed Forces since the end of World War II is the Navy's present task of supplying qualified officers and men to its rapidly expanding nuclear submarine fleet.

The Navy has 10 nuclear-powered submarines now in operation. Twenty-three more are in various stages of construction. Another four have been authorized by Congress, and there is every indication that this number will be increased before the current Congressional session adjourns.

To man this fleet will require at least 500 officers and 5,000 men, not an especially large number as present-day armed forces go. However, it is not the size, but the quality that constitutes the problem.

Every officer and every man assigned to duty in the nuclear-powered boats must be far above the average in physical fitness, adaptability and mental capability.

Each must be a thoroughly-trained, highly-qualified, experienced submariner.

All — officers and men alike — must have the quick, imaginative type of minds that will enable them to understand, operate and keep in repair the formidable array of scientific equipment, instruments and gear that are standard for the new nuclear boats.

And every one of them must be psychologically and temperamentally equipped to withstand the gruelling pressures and tensions of long underwater patrols, when they will be completely submerged for weeks and months at a time, in purely routine operations.

That is the crux of the problem. Out of sheer necessity, the nuclear submarine service must be the professional and intellectual elite of the armed forces.

As one top submariner expressed it: "We need officers and men with the mental capacity of the Ph.D. and the relaxed temperament of the veteran submariner. Unfortunately, those two qualities do not always go together."

Moreover, as Capt. F. J. Harlfinger pointed out: "They must be men with the kind of dedication that will impel them to work for Navy pay, subject to Navy discipline, willing to make the unusual peacetime Navy sacrifices of spending months at a time, year in and year out, away from homes, families, friends and all normal recreation facilities."

Also, in addition to the men who man the boats, the Navy needs several hundred highly-skilled specialists for the bases, tenders and training schools that support the nuclear submarines. Their duty will not be as rugged as that of the submariners, but neither will they be entitled to that submarine pay. But, their technical know-how must be as high — for some jobs even higher.

Until recently, all of the officers and men in the nuclear boats have been hand-picked from volunteers within the submarine force, itself a highly-select, volunteer service representing the cream of the Navy. Thus the officers and men of the nuclear service are literally skimmed from the top of the cream.

Each officer applicant must have a bachelor of science degree with a solid academic background in math and physics. Each must have successfully completed the usual six-month course at submarine school, and at least 12 months of service in sub-

marine service, with a record of "outstanding performance."

One of the tough hurdles the officer applicants must clear is the "Rickover quiz." Vice Admiral Hyman G. Rickover has insisted on interviewing all officer applicants personally and at great length, examining them as to their qualifications, their backgrounds, their schooling and training, their hobbies and their habits. To date some 50 per cent to 75 per cent have stumbled over the Rickover hurdle.

Non-commissioned officers and men are selected on the basis of outstanding service records, high mental capabilities, and unusual proficiency in electronics, electricity, mechanics, and similar technical fields.

The officers and men selected are put through a rigorous schooling and training program that varies in nature and length according to their previous training and the posts to which they are assigned. The lead time necessary to prepare an officer for nuclear duty, after his selection, ranges from 20 to 30 months; for enlisted personnel from 12 to 24 months.

Many of the officers and about one-third of the men are sent to the Weapons Firing School for a six-month course in the theory and operation of the complicated electronic aiming and firing systems, in the construction and propulsion of missiles and homing torpedoes.

Nearly all of the officers assigned to the nuclear subs, and about 40 per cent of the men, are sent to the Nuclear Power School for a six-month study of nuclear physics and its application to the power reactor. Then they are assigned to a reactor prototype for training in all of the details of the propulsion system, from the nuclear reactor to the engines.

Specially-selected officers and men are then sent on tours of various plants where the equipment they will handle is manufactured. They receive practical instruction in its construction and repair, spending anywhere from several weeks to three months at one or more of 15 different plants.

Throughout this exacting training program, any officer or man who fails to maintain the pace is quickly screened out and returned to duty in diesel-powered submarines.

Most of those who complete the course successfully are assigned to boats that are still under construction in the shipyards. They report for duty anywhere from 12 to three months before their boat is completed (depending upon rank and assignment), so that by the time it is commissioned they will be familiar with all parts of the submarine and their duties aboard.

By the time the boat puts to sea, every officer and man is expected to have a general knowledge of the entire submarine and a complete knowledge of the equipment he is assigned to handle.

An excellent illustration of just how exacting is this requirement for "complete knowledge" was cited by Capt. N. G. Ward, Commodore of the Navy's first POLARIS-firing submarine squadron (the FBM boats).

"All of the firing data for the POLARIS missile is calculated by an electronic computer, which contains more than 18,000 electronic components.

"The non-commissioned officers assigned to the POLARIS firing control system must know and understand this computer so well that they can effect emergency repairs at sea in case of any failure short of a major breakdown. These men must really know their work. If that computer is not working properly, we just don't fire."

So far the Navy has been able to find enough enlisted men in the Submarine Force with the mental capacity and the flexibility to adjust themselves to handling the complex equipment in the nuclear boats. But, with the nuclear fleet expanding so fast, the Navy has instituted a special program to recruit unusually-talented high school graduates to be specially trained for this type of duty.

The requirements are stiff. All applicants for this program must agree to serve a six-year enlistment, instead of the usual four years, if they survive the 30-to-36 month training period and the numerous examinations and screenings that accompany each phase of training.

Applicants who have graduated in the top 10 per cent of their high school class are preferred; a few are admitted from the second 10 per cent. Many of the applicants have completed one or two years of college. All must have records of excellence in math and physics.

After their regular Navy admittance examinations and "boot" training, the applicants are subjected to a series of psychological tests to determine their mental capacity, adaptability and general classification. They are given special examinations in arithmetic and mechanics. Then, depending on their own choice and their performance in the special tests and examinations, they are assigned to one of the Navy's technical schools for three to six-month courses. This prepares them for work in electronics, electricity, radio, radar, sonar, or any one of the highly specialized jobs to which submariners are assigned.

After technical school they are given the regular mental and physical examinations for submarine duty and a thorough examination by submarine psychiatrist. Those fit for submarine service are put through an eight-week course at the Submarine School and then assigned to a diesel-powered boat for sub-qualification training.

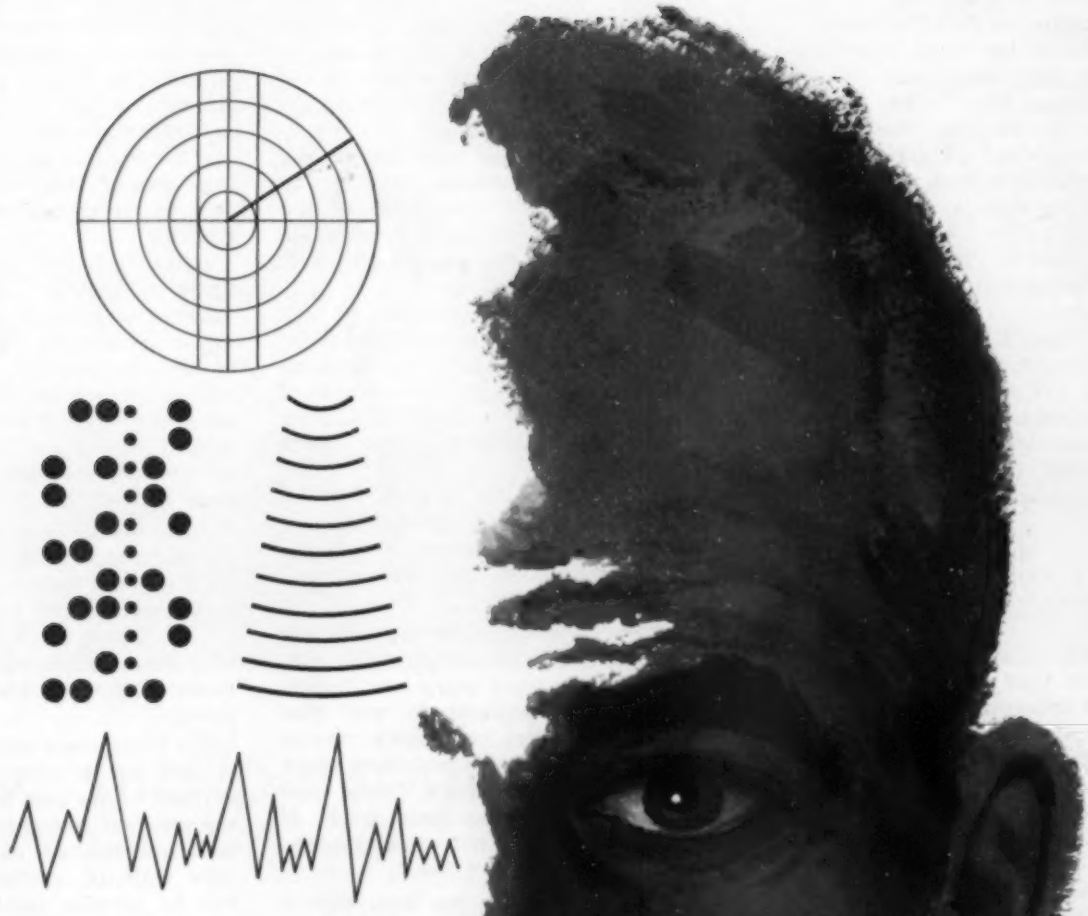
After six to 12 months service in the fleet-type boats, the men who achieve "outstanding performance" records are given examinations for Third Class Petty Officer, and those who pass are placed in the regular nuclear schooling and training program.

For youngsters still in their teens it adds up to close to three years of hard study and hard work, and the attrition rate is high. Eleven per cent are washed out during their boot training, another 19 per cent fail to survive through the Navy technical schools. The Submarine School and submarine examinations claim 10 per cent; four per cent fail to make the necessary grade in their submarine qualification; and a final 18 per cent mortality is suffered during the nuclear training period.

But for those who make the grade, the rewards are high. From the time they enter the nuclear service they have the satisfaction of belonging to THE elite of all of the elite outfits in the service. They receive submarine pay, which along with flying pay is the highest in the Navy. They are eligible for quick promotions. And there is glamor and fascination to their work.

Many of the youngsters in this program will be selected for officer training before their enlistment is completed. Those who complete their enlistment and decide to remain in the Navy will be only a step away from Chief Petty Officer, a rating that requires 12 to 20 years of service for the surface sailor to attain.

Those who decide to return to civilian life — and this applies to all of the officers and men who serve in the nuclear subs — will find that they have acquired a training that cannot be equalled anywhere. This training will qualify them for scores of highly paid jobs in the mush-



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to systems effectiveness and reliability, no matter what the application. And your assurance of compatibility is the systems engineer— trained and experienced in all phases of component, sub-system and systems design. Vitro specialists now provide **systems engineering** for: underwater weapon systems...missile ship weapon systems...fleet ballistic missile systems... data systems...test range systems. These engineers conceived, designed and developed the world's first underwater wire-guided weapon system— the Mark-39 torpedo, its director, fire control and associated equipment. They now provide systems engineering for all tactical air-defense missile ships and Polaris FBM submarines authorized for the Navy's missile fleet.

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rooming electronics industry, and the many industries that are interested in the various practical applications of nuclear energy.

There is another and very interesting opportunity offered to the officers and men who serve in the nuclear fleet, especially those assigned to the POLARIS-firing boats. This is an opportunity to take regular college courses while submerged hundreds of feet below the surface of the sea.

This is the result of an experiment pioneered by Capt. Richard B. Laning, when he was skipper of the *Seawolf* and made the record-breaking 60-day cruise completely submerged. One of Capt. Laning's concerns was maintaining high morale during the long monotonous hours off watch when officers and men try to rest and relax within the tight, crowded confines of a submarine.

"There is a limit to the time an intelligent man can keep spent reading magazines, playing cards and watching vintage movies (all nuclear subs carry projectors and stock of films) without getting bored," Captain Laning said. "Boredom can be a serious morale factor in a submarine. We felt that it was important to find ways to keep the men occupied during their off-watch hours, (submarine crews work four hours on watch, eight hours off)."

So Captain Laning conceived the idea of turning his boat into a submarine classroom. Officers and Chiefs gave lectures and demonstrations on every piece of apparatus in the boat, for the benefit of the men off watch. Thus the officers and men acquired a working knowledge of the entire submarine, not just the particular gadget or piece of machinery to which they were assigned. Classes were organized for special instructions to prepare the participants for examinations for promotion. Captain Laning broke out sets of correspondence courses on a wide variety of subjects. Officers volunteered to tutor the men in certain subjects they had studied in college.

"The entire program was voluntary," Captain Laning said. "Only officers and men who wanted to, participated. But they all wanted to. They really showed enthusiasm."

The result of the "submerged classroom" experiment was that time, which seems to almost stand still during long undersea cruises, speeded up. Morale remained at a high level. Most important, officers and crew alike felt they were achieving something worthwhile. They were increasing their knowledge of the boat and their professional efficiency. They were improving their chances of promotion. And they were improving themselves as men.

The Navy was impressed. Never before had study courses been used on the broad, intensive scale that Captain Laning employed them on the *Seawolf*, and with such satisfactory results.

Among those impressed was Captain Ward, whose POLARIS-firing submarines are expected to remain on station 60 days or more at a time, cruising completely submerged and often concealed beneath the Arctic icecap. So rigorous does the Navy regard this duty that it has decided to operate the FBM boats on a sort of a two-platoon system. At the completion of each patrol every man aboard will be relieved and assigned light duty ashore for a comparable period, while the second crew takes over the boat. Captain Ward is quite sensitive to the absolute need of maintaining high morale.

So he has worked out a program with Harvard University, which is preparing a series of special college courses for the officers and men to study while at sea. Some of the courses will deal with the sciences applied in the operation of the boat. Many will be studies of languages, economics, the humanities, subjects designed solely to broaden the minds and increase the knowledge of the men.

As each crew returns from patrol, professors and instructors will visit the bases, give lectures and hold examinations in the subjects the men have studied at sea. Students will receive college credits for each course successfully completed, credits acceptable for Bachelors', Masters', and even Doctors' degrees.

There is one other critical phase of the overall manpower problem. The Navy hopes, very earnestly, that a high percentage of the younger officers and men will choose to remain in the service, after completing their required tours of duty (officers agree to remain in the service at least two years after completing nuclear training) despite the lucrative offers from private industry.

There is some disagreement in the Navy as to just how much of a problem this is. Many nuclear skippers are convinced that a majority of the officers and men will choose to stay in. Some personnel officers, however, would be quite happy if the re-enlistment rate for the younger man exceeds 25 per cent.

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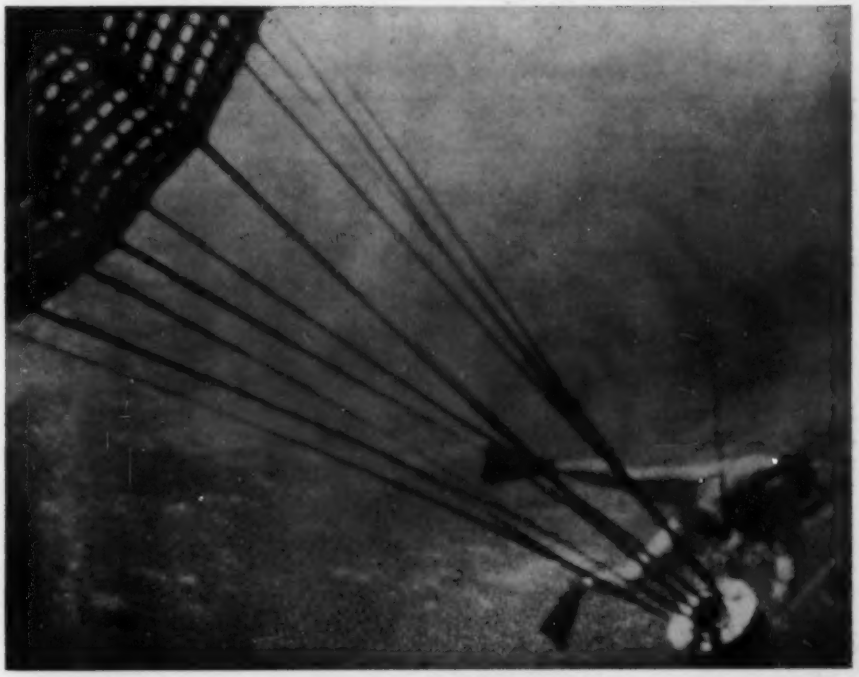

Fig. 1. Manned underwater recovery of MSVD's RVX-1 nose cone off Cape Canaveral. From blowup of 16 mm color movie footage.

optics in ASW engineering

By Alfred J. Zaehringer

When considering underwater viewing whether via the eye, photo-camera, or TV, two important factors must be considered:

1) Absorption and scattering of various spectral regions of the electromagnetic spectrum (EM).

2) Effect of intensity.

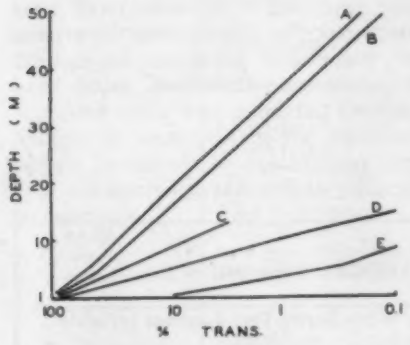

Fig. 2. Transmission vs wavelength for various depths. A) Green, 480-580 mu. B) Blue-green, 312-480 mu. C) UV, 360-420 mu. D) Red, > 600 mu. E) Red, > 700 mu.

Using these principles, the science of underwater optics has suddenly opened up new vistas in viewing. Underwater photography, for example, has played an important role in such an event as recording retrieval of ballistic missile nose cones from the ocean. *(Fig. 1)*. The new, long-range nuclear subs, also, must have "eyes"; TV is an important adjunct here.

Transmission—Water, whether it be pure, sea, or very turbid, does not absorb the various spectral regions uniformly. The water molecules absorb and scatter various wavelengths. *Fig. 2* illustrates how wavelength is important in determining how far light will be transmitted. Blue light is absorbed less but is scattered more than the red portions. This fact accounts for the blue appearance of water. However, nearer

Table 1

TRANSMISSION OF LIGHT IN WATER

Color of Illumination	Wavelength	Percent Transmitted	
		Noon Sunlight	Blue Sky Light
Violet-blue	380-490	26.7	50
Green	490-560	24.2	24.3
Yellow & Orange	560-620	19.7	12.3
Red	620-720	29.4	13.4
		100.0	100.0

shore, the water takes on a greenish appearance; this effect is due primarily to solid particles in suspension with subsequent reflection of more of the green.

The surface effect is also important. In calm, sunny weather, for example, seawater reflects about four per cent of the light. In overcast weather, about eight per cent is reflected. However, when the sun is near the horizon and there is a moderate breeze blowing, the reflection may be as much as 25 per cent. The remainder of the light is transmitted into the water. *Table 1* presents transmission data of light of various colors and wavelengths.

The Secchi disc (a white disc of 30 cm diameter) is used as a parameter of the depth penetration of light. The disc is usually lowered into the sea to the point where it becomes invisible and the length noted. *Table 2* gives depth data for various sea colors. It should be noted that the very deep blue Sargasso Sea Secchi disc depth is around 216 ft while pack ice in the Antarctic registers at 164 ft on the same scale.

Turbidity, or suspended particles, also plays an important role in optical transmission. In the northeast Atlantic, for instance, suspended particles have a density of 0.1 grams per cubic meter at a distance of about 100 miles from shore. As expected, nearer shore, the suspension density is higher. Some 20 miles offshore in the English Channel, densities of one gram per cubic meter have been recorded. *Fig. 3* illustrates the effects of suspended particles on optical transmission. Dissolved salts, suspended particles, and other sea constituents all greatly tend to reduce the penetration of the short wavelengths of the EM spectrum.

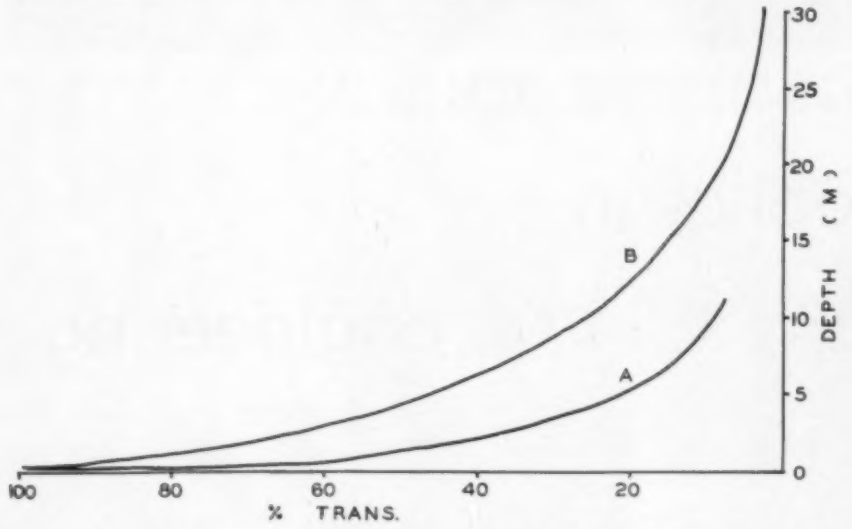

Fig. 3. Transmission (overall) for various waters. A) Inshore waters B) Ten miles into English Channel.

Table 2

SECCHI DISC DATA FOR VERTICAL VIEWING

Sea Color When Viewed From Above	Depth When Secchi Disc Becomes Invisible (feet)
Deep Blue	115
Blue	89
Blue-Green	59
Green-Blue	39
Green	29

The absorption and scattering of light, then, is a function of color and depth. This is based on the assumption that the suspended particle density does not change with depth. A mathematical law of optics has been designed to give the extinction coefficient (k) in water:

$$k = \frac{2.3\,(\log_{10} Id_1 - \log_{10} Id_2}{d_2 - d_1}$$

where k indicates the light both absorbed and scattered; and where Id_1 is the intensity at depth d_1; and where Id_2 is the intensity at depth d_2. All distances for the formula should be in meters.

Intensity — A standard way of measuring light intensity is in meter-candles. One meter-candle is equal to one lux. At noon in direct sunlight, about one half of the total radiation of the sun is in the spectral region of 360-760 mu. The intensity of light (from sun and sky) is about 130 kilolux. On a sunny winter day the intensity is about 25 kilolux at noon. On the other hand, a cloudy winter day rates about 5 kilolux. Therefore, although the color temperature may be high on a drab day, the intensity may be lowered. Therefore, intensity must be considered along with spectral transmission in underwater optics.

Fig. 4. Submersible camera can operate to 650 psi or depth of 1500 ft in fresh water.

Photography — Soon after the advent of the camera, film, and later the movies, underwater photography became a common feat even for the amateur photographer. The skin diving fad has also increased the popularity of underwater photography. Stills or movies can be made:

a) With the camera underwater, protected by a watertight case with

a plastic or glass window.

b) From a vessel equipped with a transparent window.

c) Through a glass window or wall in a tank or aquarium.

Exposures for underwater photography will depend on weather conditions, angle of sun, clarity of water, distance of subject below the surface, and the bottom color. A light meter should be used to get the proper exposure settings. As a guide, Eastman Kodak Co. has a listing of approximate exposures for underwater photography. These are given in *Table 3*. The selective absorption and scattering of various wavelengths presents a number of complex problems. In general, both red and blue tend to be absorbed so that the light underwater tends to be on the green side. With the exception of very clear water, the light penetrating is very strongly scattered; this produces a colored haze or cloudiness between camera and subject. In order to reduce the effects

Fig. 5. Underwater housing (with pan and tilt) for TV camera. Features remote lens control on camera.

of intervening haze, it is desirable to work as close to the subject as possible. This is particularly true for color work because the colored haze tends to dominate over subject colors.

Color of water varies from location to location. Even at the same location, it can change quite rapidly as a result of floating particles, rocks, soil, and minute plant and animal organisms. Sometimes the over-all tint of the water can be offset by use of color filters (such as magenta in greenish water).

Use of flash illumination can also be useful since it is more or less independent of depth; it also gives less trouble from standpoint of colored scattered haze. Exposure settings for flash, however, are highly empirical and must be determined by practical experiments.

Table 3

EXPOSURE DATA FOR UNDERWATER PHOTOGRAPHY*

Film Type	Depth	
	2-5 ft	10-20 ft
Kodak Verichrome Pan and Plus-X Stills @ 1/50 sec	f/11-f/8	f/4.5-f/3.5
Kodak Tri-X		
Movies @ 16 fps	f/22-f/16	f/8-f/5.6
Stills @ 1/50 sec	f/16-f/11	f/6.3-f/4.5
Kodachrome, Daylight		
Movies @ 16 fps	f/4	f/1.9 or f/2
Stills @ 1/25 sec	f/4.5	f/2
Ektachrome, Daylight#		
Stills @ 1/25 sec	f/8	f/3.5

*Light bottom with bright sunlight
#For dark bottoms, use of 1-2 more lens openings may be necessary (though this may still result in poorly lit subjects). Hazy light usually needs at least 1/2 a lens opening larger.

Underwater TV — Underwater TV is becoming increasingly important for:

1) "Eyes" of submerged submarines.
2) Oceanographic studies.
3) Swimming pool nuclear reactors.

The U.S. Navy Experimental Diving Unit based at the U.S. Naval Weapons Plant, Washington, D.C. has recently finished a series of tests on underwater TV systems. Tests were conducted with an illuminated target at depths ranging from 30-35 ft, with various bottom conditions, sky and sea conditions from a NOLTF Pier. Night and day tests were conducted and sea conditions of the 25 preliminary tests conducted are presented in *Table 4*. The initial results show that a commercial vidicon (photoconductive) TV system has a usable range of over six ft when the light transmission is as low as 25 per cent, when adequate artificial illumination is provided. Commercially available flood lamps (*Table 4*) in watertight sockets can be used effectively with underwater TV. The night-time performance of underwater TV is somewhat superior to the day-time performance when artificial illumination is used. More conclusive studies were recommended on underwater turbidity effects on TV. However, for these tests, the Navy emphasized that no special or exotic equipment of a developmental nature was used or evaluated.

The tests used a pickup tube, a cylindrical target, with black stripes on a white background and the light source. Poor quality photos were obtained in some cases due to: different monitor screen sizes for two types resulting in two magnification sizes, photography difficulties from the monitor set, and rolling of monitor launch, making it difficult to keep camera stationary relative to mon-

Table 4

UNDERWATER LIGHT SOURCES*

Type	Description	Electrical Data	Depth of Implosion (feet)
GE Co.- #G-25	Diving Lamps	1000 W 115 VAC	700
GE Co.- #G-48	Diving Lamps	5000 W 115 VAC	700
GE Co.- #4540	Aircraft Landing Sealed Beam	450 W 12 VDC	150
GE Co.- #4541	Aircraft Landing Sealed Beam	450 W 24 VDC	150
Tungsol- #4430	Auto Headlight Sealed Beam	6 & 12 VDC	150
Champion	Reflector, Photoflood	150 W, 115 VAC	75
Westinghouse	Reflector, Photoflood	300 W 115 VAC	60
GE Co.- #4535	Auto Spot Sealed Beam	30 W 6VDC	250

NOTE: GE Co. Types #G-25 and #G-48 **cannot** be operated out of the water. The illumination is of a low level order when operated per design data. By operating at approximately 30 per cent overvoltage, approximately six times normal illumination has been obtained without unduly shortening lamp life.

*Data supplied by Bureau of Ships.

itor. Future tests will use a 70-mm Beattie Vantion (Model E) data camera which is rigidly mounted on the same base with a standard monitor while the TV systems are being modified to operate with the same monitors.

In tests using natural illumination, water transmission never exceeded 38 per cent during the August-September period. Under conditions of high turbidity, 37.5 per cent light transmission at a depth of 20 ft, good visual recognition of the target was obtained. Any appreciable extension of range or depth for this test resulted in rapid deterioration of target detail. At 37 per cent transmission (hypothetical average for all coastal water conditions), excellent image detail may be achieved. With such water condition, during the midday period when the sky brightness is 1500 lamberts or better, a vidicon UW-TV camera should perform satisfactorily without artificial illumination to depths on the order of 60 ft. If a white sand bottom exists at 100 ft or so, the depth of effectiveness would also extend this far.

In night tests, absence of particle scattering is the explanation for improved night-time performance. Improved performance can be accomplished when a minimum of light falls within the cone shaped volume of water viewed by the UW-TV camera lens. However, examination of data indicates that day and night tests are not strictly comparable. Arrangement of lamps was different; day time tests were not performed on the same dates as night tests; and the scattering of water could have been variable. Another factor was the amount of artificial illumination which was incident on the cone of water viewed by the TV camera. For turbid water, a wide angle lens should not be used except for general scan. A lens of the proper focal length to cover required field should be used. Adequate illumination is better than high light levels. Turbidity will create haze at high light levels and this can be reproduced on the UW-TV screen. It is stated that one to two kws of incadescent illumination when properly applied will be typical of the maximum practical illuminating power for general UW use.

Table 5

UNDERWATER TV PERFORMANCE

Light Set	TV System	Range (Inches)	Day		Night	
			% Transmission	Performance score	% Transmission	Performance score
A	B	36	60	3	52	4
A	B	72	60	3	48	3
A	H	36	60	4	47	4
A	H	72	45	1	45	3
		Averages	51	2.75	48	3.5
B	B	36	58	4	52	4
B	B	72	60	3	47	2.5
B	H	36	45	5a	52.5	5
B	H	72	25	4	45	3
		Averages	47	4.0	49	3.8
C	B	36	58	4	42	4
C	B	72	60	2	50	3
C	H	36	58	5	52	5
C	H	72	58	3	42	2
		Averages	58.5	3.5	48	3.5
		Overall Averages	52	3.4	48	3.6

Light Set
A: GE Photoflood RFL 2, Type PH-2, 115 V, 500 W.
B: GE Photoflood Type EBR, 115 V, 375 W.
C: GE Reflector Spot, Type PHRSP-2, 115 V, 500 W.

TV System
B: Bludworth Marine Closed Circuit Underwater Television System Model UTH-4R-2. Mfg. by Bludworth Marine Div., Kearfoth Corp., New York, N. Y.
UTH-4R-2. Mfg. by Bludworth Marine Div., Kearfott Corp., New York, N. Y.
Designed for underwater use and consists of
1) Television camera with remote lens and iris control and a watertight housing.
2) 17-in. TV monitor (Type CF-17) mfg. by Bludworth Marine.
3) Camera control unit.

H: Hallamore Captive Television Systems. Two systems, H-1, and H-2 were used.
Mfg. by Hallamore Electronics Co., Long Beach, Calif. Consists of following:
1) Television camera with remote lens and iris control.
2) Master receiver.
3) Remote control panel.
The H-1 and H-2 systems also employ a vidicon type pickup tube. Systems were purchased as standard closed circuit TV systems. Cameras were then modified to adapt them for use in a watertight housing since it was originally designed for above surface use.

Scoring Criteria (Target Detail Resolution)	Score
a. Black and white stripes	1
b. Target body outline and (a)	2
c. Black and grey stripes and (a & b)	3
d. White and grey stripes and (a, b, & c)	4
e. Medium quality and (a, b, c, & d)	5
f. High quality	5a
g. Maximum quality	5b

As given in *Table 4*, only special diving lamps are useful beyond the 250 ft depth level. Types 25 and 48 do not, however, have any reflective element and the standard reflector filament is bulky and inefficient. The lamps also are inefficient in that the heavy filament never reaches a satisfactory temperature for useful output when operating at rated power. In the case of the GE-25, overvoltage operation on the order of 130 per cent will increase the brightness by a factor of four to five and raise the operating temperature to the area of 3,000 k. With a suitable reflector, this is a very effective underwater light. While over-voltage will shorten filament life, lamps have been used 30 hours or more.

The Navy recommends that a future program include the following:

1) Determination of maximum range and depth parameters over which useful image can be obtained when target is illuminated only by natural light.
2) Determination of the maximum range to obtain usable image when target is illuminated by various sources of artificial illumination compatible with underwater environments. Sources should include small, projection-type lamps, since they would offer little drag if used in a towed searching configuration.
3) Better controlled comparisons of day and night performance with artificial illumination.
4) Comparative studies of photoconductive and image orthicon type TV systems under identical systems.

Commercial underwater television systems are available. *Fig. 4* and *5* illustrate two such models.

1960

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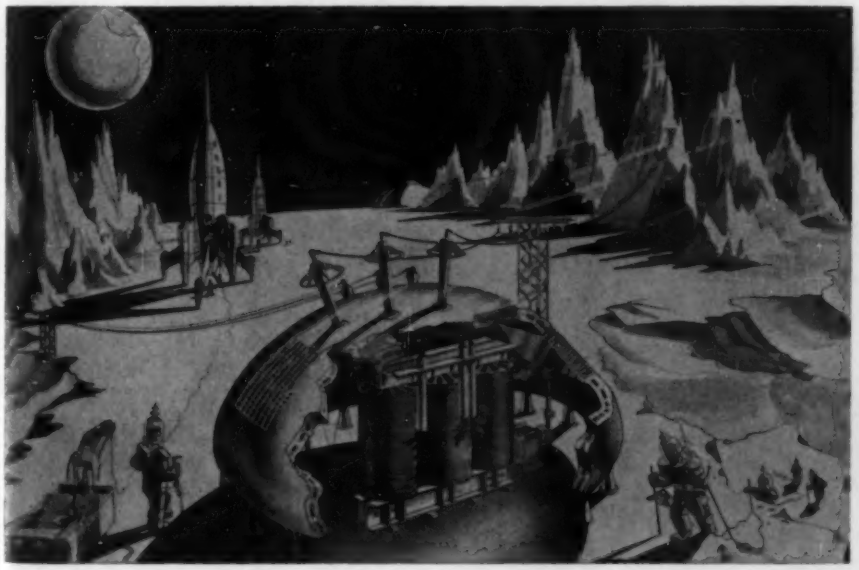

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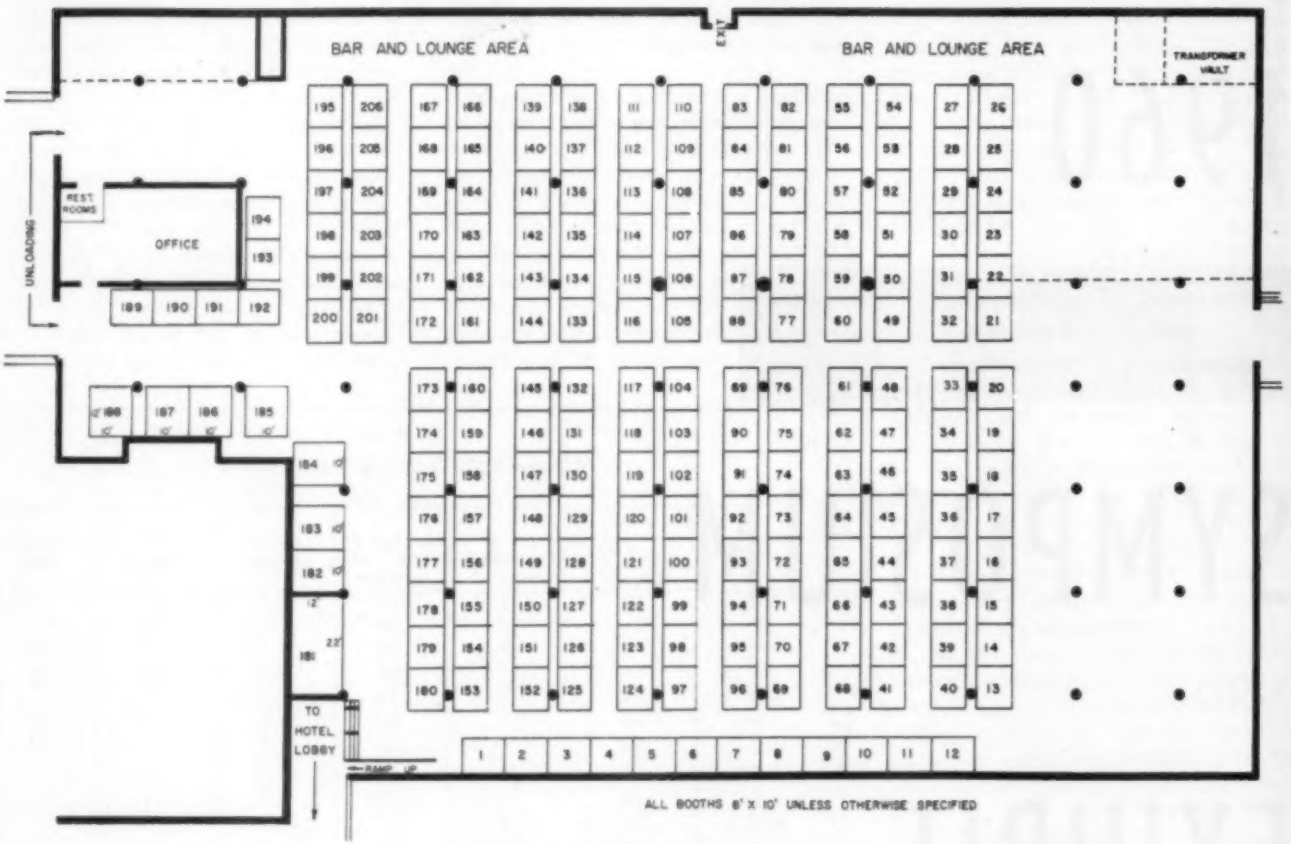

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5:00 p.m. **GSE Exhibit Opens**

5:00 p.m. ***Reception in Exhibit Hall***

7:00 p.m. GSE Film Presentations
Air Force—Army—Industry,
Main Ball Room

SEPTEMBER 8

8:00 a.m.-
11:00 a.m. Registration in Shoreham Lobby

8:00 a.m. **GSE Exhibit Opens**
(Continental Breakfast in Exhibit Hall)

9:30 a.m. **PANEL I** ***"NASA's GSE Requirements"***
Chairman: Addison Rothrock, NASA
Industry and NASA Participants,
Main Ball Room

10:00 a.m. **Exhibit opens for Dept. of Defense personnel**

11:00 a.m. **Army Buses leave for Fort Belvoir (40 minutes)**
(from Main Entrance, Shoreham Hotel)

12:00 noon **Field Program, U. S. Army Corps of Engineers;** Live GSE Demonstrations,** *"Army GSE Requirements, Personnel Training and Procurement."* Lunch.
Host: Lt. Gen. Emerson C. Itschner

4:00 p.m. **Return to Shoreham Hotel (Army Buses, 40 minutes)**

5:00 p.m. **Exhibit Closes for Dept. of Defense personnel**

6:00 p.m. **Cocktails in Exhibit Hall**

7:30 p.m. **G S E DINNER** (Informal), Terrace Banquet Room. Guest Speaker: To be announced (30 minutes)
Presentation of G S E Industry Awards (10 minutes)
Chairman: Erik Bergaust, GSE Publisher

SEPTEMBER 9

8:00 a.m. **GSE Exhibit Opens**
8:00 a.m. *(Continental Breakfast in Exhibit Hall)*

9:30 a.m. **PANEL II** *"Air Force Ground Support Equipment Electronic Requirements"*
Chairman: Lt. Col. Frederick F. Swan, Support Equipment Branch of the Directo-

1960

III GSE

SYMPOSIUM
PROGRAM

1960 GSE SYMPOSIUM

Specifications for lunar support equipment will be outlined at the *1960 GSE Symposium* in Washington, D. C. September 7th, 8th and 9th. However, most important will be the industry-military panel sessions on *where you should go to obtain more GSE business* from the Army, Navy, Air Force and NASA — their new procurement plans, reorganizations and trends. More than 50 top military and civilian GSE experts will discuss today's engineering *procurement and purchasing* situation. Only management and engineering personnel interested in more sales should attend. THIS IS NOT A SOCIETY OR ASSOCIATION MEETING. THE NON-PROFIT 1960 GSE SYMPOSIUM IS SPONSORED BY GSE MAGAZINE. THIS MEETING IS A SERVICE TO INDUSTRY. NO SECRET OR CLASSIFIED SESSIONS!

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Yes, I will attend the 1960 GSE Symposium at the Shoreham Hotel, September 7, 8, 9, 1960, and I am enclosing my check/money order for $20.00 registration fee. I understand that this fee covers all panel discussions and briefings as well as lunch and dinner. Tickets and final program will be sent to me promptly.

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Your Host Sept. 8

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Air Force and Industry Participants,

Main Ball Room

9:30 a.m. **PANEL III** ***"Business Opportunities in Missile Site Construction and Architect Engineering"***

Chairman: E. E. Halmos, Jr., Engineering Editor, GSE Magazine

Military and Industry Participants,

The Blue Room

12:00 noon **Cocktails and Luncheon,**

Terrace Banquet Room

Speaker: Dr. Walter R. Dornberger, Vice President, Bell Aircraft Corp.

2:30 p.m. **PANEL IV** ***"Army, Navy, Air Force Mechanical GSE for Tomorrow"***

Chairman: Anthony S. Mrozek, Vice President Ingersoll - Kalamazoo Div., Borg - Warner Corp.

Military and Industry Participants,

Main Ball Room

* $20.00 Registration Fee Covers Entire Program.

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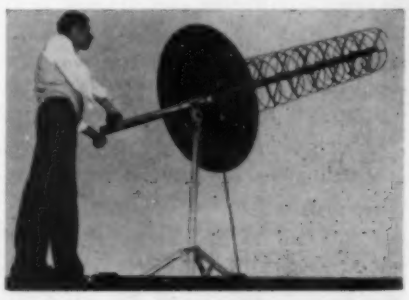


puget sound to get nuclear sub work?

By William L. Sturdevant, Jr.

Lockheed Aircraft Corp., already diversifying into ASW and oceanography, may one day find itself in nuclear sub construction work through a recently-acquired subsidiary, informed sources in Washington believe.

The subsidiary, acquired in April 1959, is the Puget Sound Bridge & Dry Dock Co., Seattle. A Navy contract with Puget Sound would contribute to further industrial dispersal in this program.

Puget Sound has already built two destroyers for the Navy, and is converting two other Navy ships—one for underwater research work and the other for PROJECT HOPE.

The destroyer *USS Turner Joy*, named for the Admiral who won distinction in World War II battles in the Pacific and later during the Korean War, was the first to be delivered to the Navy following Lockheed's purchase of Puget Sound.

Last Spring Puget Sound won a contract to build three guided missile (TARTAR) destroyers. It is said to be the largest single peacetime shipbuilding contract in the area, and Puget Sound won it over eight competitors.

Lockheed has listed the Navy as a customer since 1935, having delivered hundreds of naval aircraft in that period. It is manager for the POLARIS fleet ballistic missile program. Lockheed also is involved in oceanography research, and its Puget Sound subsidiary has been engaged for the past six months in converting the rescue ship *USS Snatch* into a vessel for underwater research work by the Scripps Institution of Oceanography. The ship being converted for PROJECT HOPE is the *USS Consolation*, a hospital ship.

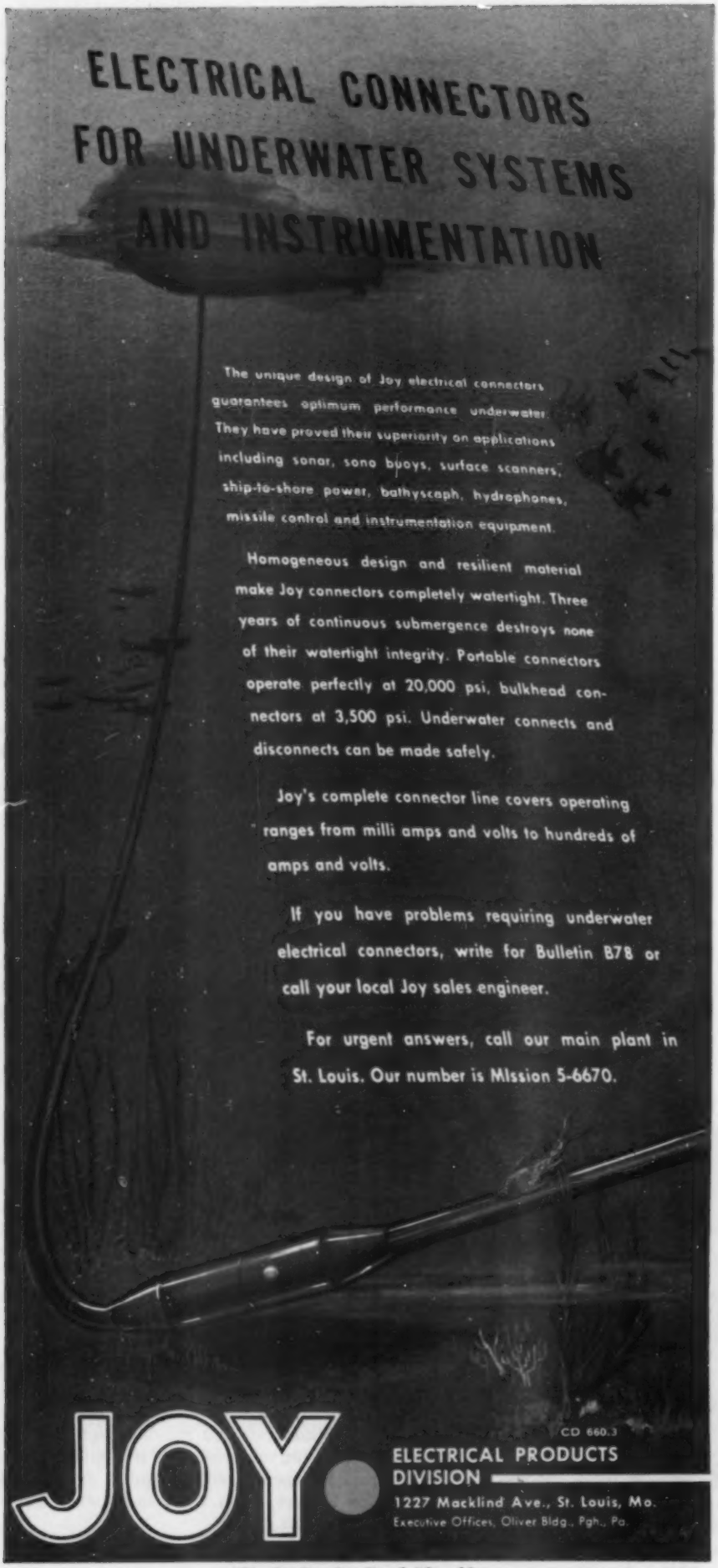
An indication of Lockheed's growing interest in submarine work was given in a recent statement declaring, "Aware of the vital need for advanced equipment to detect and identify underwater vessels, we are intensifying our submarine and anti-submarine defense studies." Continuing, Lockheed said:

"While we investigate the submarine business, we intend also to see what can be done in the area of applying nuclear propulsion to surface craft, drawing upon the growing nuclear capabilities of our Georgia and Missiles and Space divisions. The Puget Sound company, with its long experience and abilities, can help a great deal in our efforts to penetrate these promising fields."

Potential subcontractors will be interested in Puget Sound's procurement policies. Outright competitive bidding forms the basis of it. Most of the material falls into either highly specialized or quite general in nature, with little in-between categories.

In the case of major components, specifications are often written

Lockheed and Puget Sound officials meet in Seattle: From left, C. S. Gross, Lockheed President; Mayor Clinton of Seattle; Cyril Chappellet, a Lockheed Senior VP; J. G. McCurdy, Puget Sound President; and H. W. McCurdy, Puget Sound Board Chairman and Lockheed board member.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around particular makes of equipment—not to exclude anyone, but simply as a guide. Actual purchase in many cases is the same make as the "lead" yard buys, to simplify plan work and interferences during construction. Nearly all equipment is purchased under military specification for naval vessels, where a bidder must meet a qualification test before being eligible to bid. In the case of commercial vessels, there are corresponding regulatory agencies whose specifications must be met.

Invitations to bid are sent to all known and eligible bidders. Purchases are made after evaluation with respect to:

1) Price
2) Minimized labor costs to fit the equipment to existing plans
3) Availability of service and parts, and
4) Delivery capabilities.

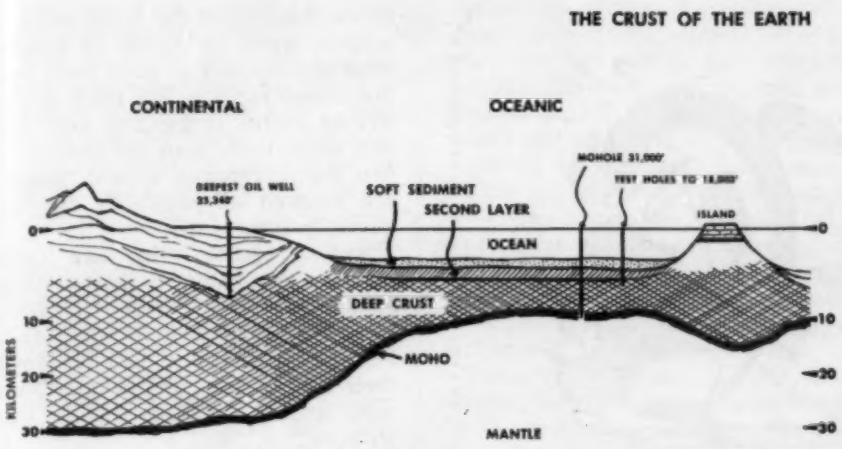
As in the case of most large contracts, awards for large vessel construction are usually announced publicly.

Puget Sound Bridge and Dry Dock Company is the third largest shipyard in operation on the West Coast and among the ten largest in the nation. Its facilities include two shipyards covering 28 acres, three floating dry docks, two building docks, a launching way, six piers, five cranes, offices, and 50,000 sq ft of shops. All this is carried on the books at a valuation of $8.1 million.

Puget Sound will also assist Lockheed in bidding for missile support equipment orders. (About half the money the Government spends for missiles goes into special ground handling equipment and huge concrete installations.) Lockheed feels that Puget Sound's experience in constructing military bases will strengthen its position in this field.

H. W. McCurdy is Chairman of Puget Sound, and James G. McCurdy is President. The latter is also Chairman of Colby Steel and Manufacturing Inc., of Seattle, and Colby Crane and Manufacturing, Ltd., of Vancouver, B. C., both of which were acquired by Lockheed in February, 1960. The Colby companies annually produce cranes, elevators, hoists and other materials handling equipment valued at approximately $2 million.

Also in February Lockheed agreed to purchase a 50 per cent interest in and provide management assistance to Grand Central Rocket Co., the nation's fourth largest producer of rocket motors and solid fuels.



the oceanography challenge

By E. E. Halmos, Jr.

Yes, the world's oceans are more than highways for commerce, more than hiding places for attacking or defending warships. They are also the source of enormous quantities of food, energy and materials that will become increasingly important as world populations increase, and Man continues to deplete the limited resources of his land areas.

At the moment, the United States seems to have at least a slight lead in this area—largely due to the efforts of the U.S. Navy and other government (and commercial) interests. But the Soviets are pulling up fast enough to have caused grave concern among those who realize the importance of such study.

Here's what's under way:

Some 11 U.S. government departments and agencies are directly engaged in some form of oceanographic research. Their efforts range from soundings of the seven-mile-deep Marianas Trench in the Pacific Ocean and explorations by atomic-powered submarines under the North Pole icecap, to investigations of the habits and characteristics of various kinds of fish and sea plants, and of the courses, intensities and characteristics of known ocean currents.

In the current fiscal year, a total of some $13 million has been appropriated by the federal government for this work, and Congress is now considering recommendations that the U.S. spend about $65 million a year for a ten-year period.

In the budget for Fiscal Year 1961, already approved by Congressional committees, there is a $2.5 million appropriation for construction of a new oceanographic vessel for the Bureau of Commercial Fisheries.

The Coast and Geodetic Survey's survey ship *Explorer*, scheduled for transfer from Seattle to Norfolk, Va., via the Panama Canal will spend an extra two months on the voyage, to make special oceanographic studies.

The special House Subcommittee on Oceanography has recommended that the U.S.' first nuclear-power surface ship, the *NS Savannah*, scheduled to go into operation this year under Maritime Commission management, "double in brass" in its first two years as an oceanographic survey ship.

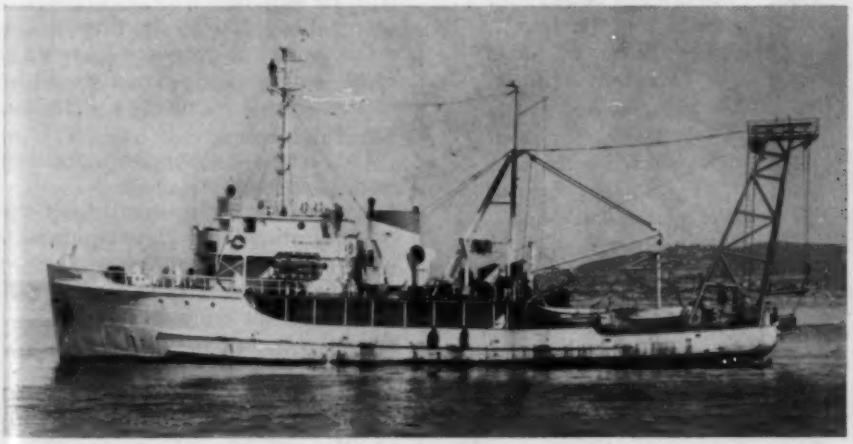
The National Research Council (a branch of the National Academy of Sciences) is pushing at every opportunity to support its monumental report of last summer, which sparked the formation of the special House subcommittee, and has formed the basis for overall planning. The report called for a total (over 10 years) of $267 million for construction of new research vessels, $90 million for new shore facilities, with the Navy getting the lion's share of the $651 million, 10-year total to be expended.

Government departments and agencies now involved in oceanographic studies incude: Navy, Coast Guard, Coast and Geodetic Survey, Bureau of Commercial Fisheries, Maritime Administration, National Science Foundation, U.S. Office of Education, the Atomic Energy Commission, the Bureau of Mines, Weather Bureau, and the Beach Erosion Board of the U.S. Army.

There are now several bills before Congress that would establish an overall national policy on oceanographic studies, provide for more complete coordination of all these activities.

• **Russia active too** — Moving fast to catch up in this important field, Russia has made no secret of its own intensive efforts to learn more about the world's oceans. Although most of the Russian activity has been conducted in the guise of "fishing information," the Soviets are known to have at least 22 vessels (including the *Mikhail Lomonosov* — world's largest research vessel) in action, as well as submarines.

These ships have been and are making explorations in the Atlantic and Pacific Oceans, in the Polar seas and in the Antartic, and will be extended to the Indian Ocean this year. Russian authorities admit that as "fishing information" gatherers, these expeditions — including the government support of fleets of



Unique oceanography research vessel, *Spencer F. Baird*, of the Scripps Institution of Oceanography.

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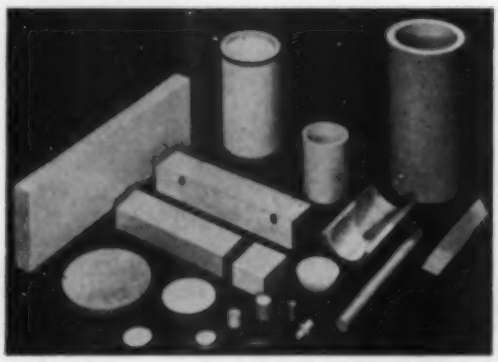

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trawlers equipped for some oceanographic work by means of supply ships and tankers — have been losing money rapidly. But their objective, of course, is scientific information much more than the finding of new fishing grounds, so such "losses" are counted as negligible by the Soviet government.

And of course, these two great nations are not alone in these studies. Japan, Denmark, West Germany, Norway, Great Britain and other seafaring nations also have equipped their fishing fleets and naval vessels with scientific instruments for this purpose.

• **Why the oceans?** — It is a sad fact that, although the oceans have long been familiar to Man as avenues of commerce, conquest and communications, he probably knows less about them than he now knows about outer space. In the future, knowledge of these vast areas on the earth will certainly be as important as anything else the human race can learn. Of prime importance, right now, is the military significance. But there are many other considerations.

On the military side, the development of nuclear-powered submarines, capable of being built to relatively huge sizes, of extensive voyages under the surface without need for surfacing, great speeds, huge cargos — and of delivering devastating attack on an enemy via such missiles as the U.S.-built POLARIS — exact knowledge of the ocean geography, currents and other conditions is an absolute must.

There are very few land areas that could not be attacked by missiles fired from such a submarine. But an exact knowledge of the coastlines to be approached, of undersea "mountains," reefs and other danger areas, the effects of currents, temperatures and the like is also necessary, if such an attack (or defensive threat) is to be mounted with accuracy and reasonable safety to the attackers.

Obviously, an intimate knowledge of his own shoreline area would be of inestimable value to a defender, too.

But there are other considerations, equally important:

• **Food reservoir** — Much of the world's estimated 2-billion-plus population depends heavily on seafood for its existence. Fish in many forms are a crop that men have harvested since the beginning of recorded time.

United States commercial fishermen in 1959, for example, caught an estimated total of 5.5 billion pounds of all types of seafood — and the U.S. is not the top fishing nation in the world (Japanese fishermen

landed nearly 8 billion pounds in the same year, for instance).

And scientists are beginning to find many other uses for fisheries products beyond human food — they are used as fertilizers, as the base for animal feeds, in many commercial processes. A recent discovery on the medical side is also of great interest — it has been found that certain components of fish-oils can deter the formation of cholesterol in the human body (and cholesterol is blamed as one of the great causes of heart diseases).

But the sad fact is that no one really knows how many fish there are in the sea — or how many kinds of fish, or how many kinds of fish are edible or usable, or where many of these species come from, what they feed on, how they propagate, and many other things.

• **Other resources** — It has long been known, also, that the oceans contain (or hide) vast resources other than the fish that live in them.

Hugh deposits of oil have already been found and exploited to some extent in shallower ocean areas such as the Caribbean, off the coasts of Saudi Arabia, Lake Maracaibo in Venezuela, and elsewhere. But vastly greater submerged oilfields may exist elsewhere.

The sea waters themselves contain many minerals — some of which are already being extracted — and there are certainly huge deposits of other minerals. Even seaweeds of many kinds are used, both for extraction of commercial and industrial products, and in some cases as foods.

And probably the most important possibility of seawater is the water itself — if it can be rendered fit for human and animal consumption. Most ocean-going vessels now "make" their own drinking water, and in some areas — such as Dahran and Saudi Arabia — waste heat from oil refining is used to distill water. But in the past two years, the U.S. Government, through its Office of Saline Water, is making serious scientific efforts to find an economical way to make this water drinkable. One other point of great scientific interest is the fact that sediments on the bottom of the deepest parts of the oceans may be of tremendous value in helping to trace the history and development of the earth itself. One U.S. experiment — "Operation Mohole," scheduled to be conducted off the coast of Puerto Rico this year — is aimed at cutting through the earth's crust, to see what lies below.

• **Waste disposal** — A direct tie to these considerations is the matter of disposal of wastes — very particularly radioactive wastes. Man is one of the few animals that actually will foul his own nest, through the disposal of the products of his industry and his living.

As of this moment, the Atomic Energy Commission has collected something more than 50,000,000 gallons of liquid radioactive waste that is so powerful that AEC doesn't know what to do with it. And as use of nuclear power burgeons, this collection will increase enormously.

The problem is this: AEC is now storing this material in impervious tanks, at various underground depots. But the tanks will rot away long before the radioactivity has diminished by even a tiny percentage.

Obvious place to get rid of this material is into the sea — in the belief that the enormous quantity of water will so dissipate the radioactivity as to render it harmless. But AEC — and many others — is afraid to do this, without greater knowledge, for instance, of ocean currents to insure that concentrated amounts of radioactivity are not swept into some area where they may do inestimable damage. Vastly greater information about water temperatures, pressures and composition must also be collected — as well as much more information on biological effects on fish and plants — before this material can be safely dumped.

And there is, in addition, the huge quantities of raw sewage, industrial wastes of all kinds, oil and chemicals, that is being discharged into the seas every second of every day, all over the world.

• **Weather** — One more important point: The world's oceans are the great "weather breeders" for the land areas — they present the huge, uniform surfaces that create weather fronts. If man is ever to control the weather, he must understand the oceans. (The U.S. Weather Bureau has asked $8 million for next year, to study hurricanes and other weather phenomena, and their origin.)

At some not-too-distant date in the future, most of the world's navies and commercial shipping fleets will travel under the ocean, rather than on it, and so will be generally impervious to weather conditions above. But they will need accurate information about the ocean geography, its currents and the like.

But land areas will always be affected by weather — the Sahara is a desert only because it doesn't have enough rain.

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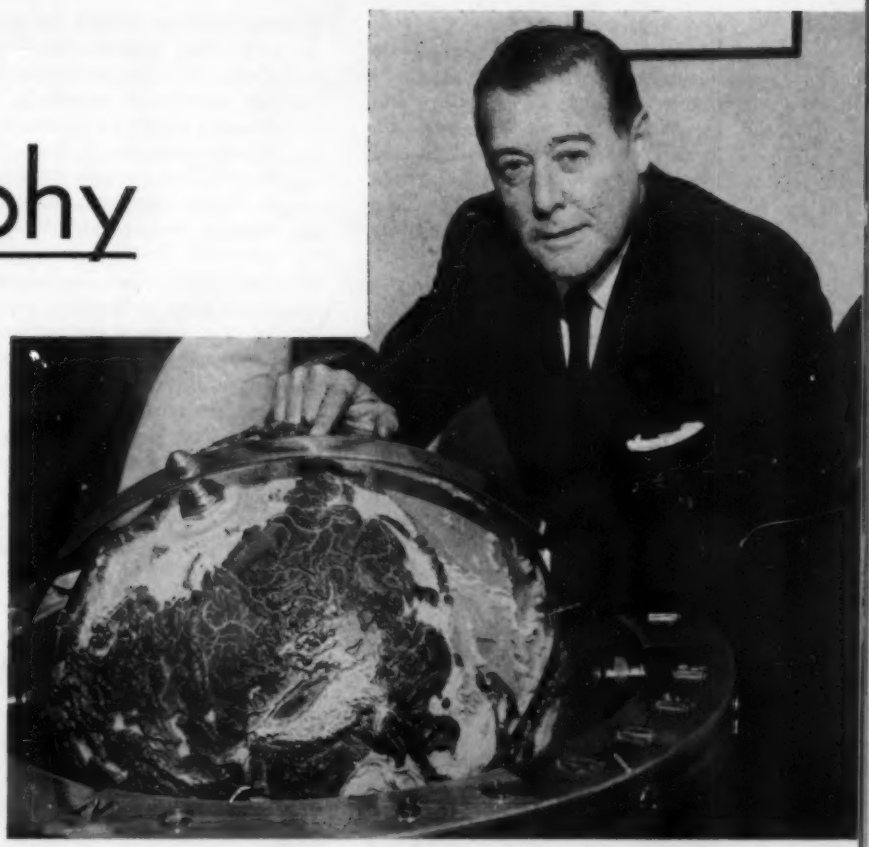


exclusive staff interview
with Senator Warren G. Magnuson

Q. *What is the basic reason for S. 2692, the Marine Sciences and Research Act?*

A. In this scientific age we must acquire far more knowledge of the oceans than we have at present, or have the research facilities to obtain. Inner space has now become vastly important to our security, economy and health.

Submarines, prior to the *Nautilus*, were primarily surface ships, with an ability to submerge at intervals. But the nuclear submarine has changed the pattern of naval warfare; ultimately it will change that of commercial navigation. This means we must know more about what lies under the surface of the ocean.

Confirming that Russia expects future naval wars to be fought under the seas, not on them, Premier Krushchev told the Supreme Soviet at its recent session:

"In the Navy the submarine fleet assumes great importance while surface ships can no longer play the part they did in the past."

The latest edition of Jane's Fighting Ships states:

"It is expected that in 10 years time all major warships will be nuclear powered. The strategic advantages are so staggering that the change is bound to come."

Other nations have, or soon will have, nuclear submarines plying the ocean depths. Will we, in time of emergency, be able to detect them? Will we be able to spot them before they come within a range from which they can launch missiles at our seaports and great industrial centers? If they do attack, will we be able to destroy them?

These are questions for oceanographers, scientists and technicians to answer.

S. 2692 authorizes funds and facilities for these specialized scientists that will ultimately enable them to supply answers —affirmative answers.

Oceanographers also will determine how our submarines may operate silently, secretly, and with maximum efficiency.

Other nations are preparing also for another kind of undersea warfare—mine warfare. Today's mines are more diabolical than any previously used.

Submarines, airplanes, fishing vessels and scows all lay mines. Crews on North Korean junks and sampans planted 3,000 Russian-made contact mines, plus a few magnetics, at Wonsan in the Korean conflict, causing more than 200 casualties and delaying American landings eight crucial days.

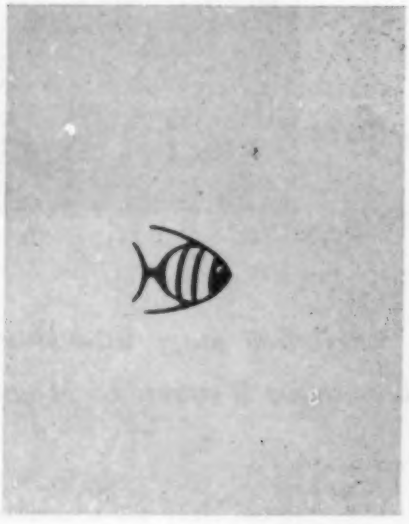
Our ability to counter an undersea mine threat in the event of a future war rests with our scientists and technologists. In both anti-submarine warfare

and anti-mine warfare we will need the counsel of specialists in underwater acoustics (including knowledge of sounds made by fish and other forms of life in the sea), wave pressures and water density, magnetism, gravity, and bottom topography.

More research — physical, biological, chemical and geological — than we have now will be required. S. 2692 aims at providing facilities and training scientists for such research.

We must also find out what amounts of radioactive wastes the nations of the world can safely dump into the oceans.

Today 25 nations are operating nuclear reactors for peaceful or military purposes or both. Six of these are Soviet-bloc nations; nineteen are Free World nations.



...oceanography is a whole family of important things...

Inevitably part of the radioactive wastes from these reactors will reach the sea. As the nuclear age advances, the quantity will increase. Dr. Dayton E. Carritt of Johns Hopkins University told the Senate Commerce Committee recently:

"Contamination of the world's oceans is therefore assured."

These waste products cannot be destroyed; they can only be dispersed or isolated. But can this be done adequately? Scientists do not know. The ocean, in addition to being a universal catch basin, is a vast mixing bowl.

Life exists in the oceans to their lowest depths. The food chain begins with phytoplankton and zooplankton and ends with the higher orders of fish and shellfish. What effect will radioactive wastes have on the life that makes up this food chain? S. 2692 authorizes funds for extensive research by the Atomic Energy Commission and other agencies to find the answer. Then we can determine, as a nation, our own disposal procedure and establish our own controls. But other nations can continue, if they choose, to dump their own radioactive wastes into the oceans indiscriminately. Obviously, an international agreement must be reached on this pressing problem.

Before there is an international agreement there must be an international conference—not a so-called summit conference but one in which nuclear and marine scientists have the leading roles. At such a conference our scientists would have to know many things about the oceans that admittedly they do not know now. These things include, according to Dr. Roger Revelle and Dr. Milner B. Schaefer of Scripps Institution of Oceanography:

1) Dispersion in the upper mixed layer, 2) Circulation in the intermediate and deep layers, 3) Exchange between the surface layer and deeper layers, 4) Sedimentation processes, 5) Effects of the biosphere on the distribution and circulation of elements, 6) Uptake and retention of elements by organisms used as food for man, and 7) Effects of atomic radiation on populations of marine organisms.

S. 2692 not only would authorize funds and provide a mechanism for obtaining this knowledge, but it calls for an interchange of information between our scientists and those of other nations, subject of course, to statutory security provisions. Moreover, it calls for development of formal international cooperation in the marine sciences—on a reciprocal basis subject to approval of the President.

S. 2692 also authorizes funds for a greatly expanded study of ocean resources. Those most utilized today are the food fishes and liquid fuels. Those of tomorrow will include metallic minerals and antibiotics.

The world population is increasing far more rapidly than the capacity to produce meat animals. Where will we get our proteins? We will have to supplement our protein needs by food from the sea, as Japan and other heavily populated countries do. Russia is making a massive effort to harvest the oceans. Red China is making desperate efforts to double its sea-food production.

Competition for the resources of the richest grounds and banks has increased, with a result that the harvest of some of our most important food fish is being rapidly depleted. Our own catch is dwindling. We should be exploring for new fisheries and conducting wide fisheries research. Other nations are rapidly expanding their fisheries research fleets, while that of the United States is shrinking.

S. 2692 would authorize the tools to carry on this important research and provide for studies

of the economic and legal aspects of fisheries and the utilization of marine products. Envisioned also are long-range projects of "fertilizing" the less productive areas of the ocean.

Like our fisheries, our continental oil fields are becoming depleted. Our petroleum geologists look to the offshore possibilities for future supply. Forty per cent of the world's reserves, they have estimated, lie beneath continental shelves. S. 2692 proposes government assistance in scientific studies that will aid in the development of these rich and hidden resources.

The bill also would further deep-sea research into the metallic wealth that in some areas literally carpets the ocean floor, usually in the form of nodules containing manganese, cobalt, nickel, and other metals.

Only in the past few years have we known of the massive sub-surface currents running counter to and far below the surface currents on our navigation charts. These subterranean currents will be important to future submarine operations.

Possibilities for acquiring knowledge of the oceans appear unlimited, given the scientific manpower, the scientific ships, the scientific instruments. Until science reached its present-day complexity, research could be conducted with private or institutional funds. Today in many fields it is much too costly. Government grants will assure that the required research be done.

Federal financing in the scientific field is recent, but not new. It was found necessary when the nation embarked on its atomic program. It was found necessary when the nation embarked on its space program. It is necessary now when the nation is confronted with the necessity of pursuing a great program of marine science and oceanography.

Q. *Marine scientists charge that we have a 25-year replacement program which must reach fulfillment in the next ten years. Do you think that time may run out on us?*

A. The question refers to research ships. The scientists quoted are eminent civilian oceanographers with the Office of Naval Research. They are top men in their field and I am sure they know what they are talking about. Whether we get ahead of the Russian sub menace or not depends on 1) what we do, and 2) what the Russians are doing.

The Russians have twice as many research ships as we have and they top us eight to one in tonnage. Most of their research ships are young and some of them are new, specifically constructed for scientific study of the oceans. They are operating in all oceans.

Our ships are old. All of them are reconversions with exception of the *Atlantis*, of 298 tons, built in 1931. They are modified ex-tugs, trawlers, draggers and overhauled surplus auxiliary naval craft — a motley assortment of marine has-beens ill-suited for their present vital mission and uneconomic to operate.

The Navy is constructing one new 80-ton research vessel and has funds to construct another of approximately 1,200 tons. The National Science Foundation has taken initial steps to construct a vessel similar to the latter.

Russia has 10 research ships of from 1,500 to 12,000 tons and has ships of 5,000 and 6,000 tons under construction. Her research ships are operating in all oceans.

Oceanographer Richard C. Vetter says:

"Urgently needed is a clear cut, long-range program designed to regain our country's lost leadership in the exploration of inner space."

S. 2692 is designed to provide such a program. If this, or similar legislation, is not adopted, and if Russia continues her efforts in oceanography which Rear Admiral John T. Hayward, Assistant Chief of Naval Operations, has described as "massive, of high caliber, and designed to establish and demonstrate world leadership," time might well run out on us.

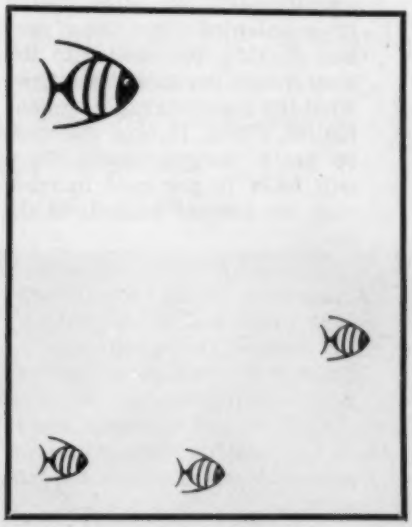
I hope that does not happen. I am confident it will not.

Q. *Government activity is directly linked to the national economy. What are the economic benefits to be reaped from a positive conclusion to your measure?*

A. Three of the economic benefits were touched on in my answer to the first question. They embrace food, liquid fuels, and potential recovery of critical and strategic minerals. There are others.

Scientific knowledge of the ocean depths will revolutionize

Senator Warren G. Magnuson (D., Wash.), author of the Marine Sciences and Research Act, which was passed by the U. S. Senate June 23, discusses the measure in the accompanying staff interview. Senator Magnuson is Chairman of the Senate Committee on Interstate and Foreign Commerce and member of the Senate Committees on Appropriations and Aeronautical and Space Sciences. He served during World War II as a lieutenant commander with the Pacific Fleet. He is author of the National Science Foundation Act.



. . . the Russians have twice as many research ships as we have . . .

trade and commerce. Not only our submarines, but balk carriers of the future will be submersibles, nuclear propelled. They will cross oceans at approximately twice the speed of surface craft.

They will also be safer. Masters of tomorrow's submersibles, with the help of advanced sonar systems, will, in effect, see better, farther and more clearly under water than they would from the bridge of ships tossing on the waves.

Hurricanes are sea-born. Oceanographers have found some interesting clues to the origin of hurricanes based on temperatures of ocean waters. Tomorrow we may be able to predict them even before they form.

This industrial civilization, scientists tell me, is producing unprecedented quantities of carbon dioxide. Released into the atmosphere it causes heating — what the scientists call a "greenhouse" effect. During the next 50 years, they estimate, there will be a 70 per cent increase over the present quantity in the air.

How much of this will remain suspended in the atmosphere? How much will be absorbed by the oceans? The answer may indicate how rapidly we may expect a significant heating over the planet and increased aridity in our western states. Only our scientists can produce the answer.

Marine boring and fouling organisms cause half a billion dollars damage annually to piles, floats, wooden drydocks and ships' bottoms. The Navy will reap great savings when such organisms are eliminated entirely.

Beach erosion causes millions of dollars loss in shore properties each year. S. 2692 is being amended to include the Beach Erosion Board of the Army Corps of Engineers and its scientific research activities in the 10-year-program of expanded oceanography.

In my opinion the economic benefits to be derived from S. 2692 will more than justify the proposed cost over the 10-year period — a cost which, incidentally, will amount to only six per cent annually of the amount we will spend this year on space sciences (excluding all military applications) alone.

Q. *Does S. 2692 create further proliferation among Federal agencies?*

A. No. S. 2692 creates no new agency. What it does is broaden the work in existing agencies which have duties or responsibilities connected with the oceans, and in one agency it proposes to unify that agency's marine functions. This is the National Science Foundation, where programs now dispersed among three Divisions and two Offices would be consolidated in a Division of Marine Sciences, with a divisional committee composed of scientists representing non-government institutions and government agencies.

This consolidation should create a harmony of interest and effort in the marine sciences on the part of scientists with the Foundation, a harmony that I have reason to believe does not now exist.

It was thought preferable to expand the oceanographic work in existing agencies rather than create a new agency because many of these agencies have a long and historic record of interest in the oceans. On the other hand, new agencies were desirable for the new sciences of atomic energy and space.

Q. *Is the Office of Naval Research getting a sufficient share of the Navy dollar to do the complex oceanographic research required in this age of nuclear submarines and possible underwater warfare?*

A. The over-all Navy budget for fiscal 1960 was $11.226 billion and the budget presented for fiscal 1961 comes to $12.013 billion.

The budget for the Office of Naval Research for fiscal 1960 was approximately $99 million and that for the coming fiscal year is about the same. But ONR has many research and scientific activities other than oceanography, among them patent studies, psychological research, metallurgy and aeronautical research. For oceanographic research in fiscal 1960 ONR received $12.8 million. Present Navy plans are to increase this amount to $16.724 million for fiscal 1961.

This is a substantial increase of nearly $4 million—occasioned, I think, largely by the report of the Committee on Oceanography, by the interest taken in Congress in that report, which includes Senate adoption of S. Res. 136 last year, and consideration by the Senate Committee on Interstate and Foreign Commerce this year of S. 2692.

Even with the prospective increase for fiscal 1961 the funds anticipated for the Office of Naval Research for oceanographic research would represent 0.13 per cent of the entire naval budget. This is a very small amount if the Navy is as dependent on oceanographic research as the Navy itself says it is.

Q. *Why, in your view, has the Soviet Union undertaken a crash program in oceanography?*

A. The reason, in my opinion, is that Russia seeks to dominate the world, and to rule the world she must first control the oceans. This would give Russia dominion over 95 per cent of the surface of the Earth. The remaining 5 per cent would be menaced by missile-firing Soviet submarines hovering along our continental shelf.

Control of the oceans would enable the Red bloc to fragmentize the Free World alliance, cut the lifelines to the United States, and block our supply lines to 58 overseas allies with which we have mutual security pacts of one kind or another.

Russia's submarine fleet is the largest in the world — larger than that of all the free world nations combined. Since World War II she has outstripped us in submarine tonnage six to one. Her mine fleet is the largest in the world. Her research fleet is the largest in the world. Her ocean research activities have been the most extensive in history, and she has the largest number of professional oceanographers afloat of any nation.

I doubt very much if her marine scientists can match ours in ability, but they certainly have more ships and floating laboratories to work from and more equipment to work with.

S. 2692 would, within ten years time, double our facilities for scientific research on and in the ocean. And it would double the number of scientists trained to do this work, which in my opinion is vital to our survival as a free nation.

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cover story

helicopters for ASW

"Helicopters have come as far in the last ten years as the airplane did from the Wright Brothers to World War II."

This comment by a naval officer high up in the planning of anti-submarine warfare (ASW) explains why helicopters are considered important cogs in the U.S. Navy's ASW machine.

Already helicopters are powered

Left, Republic's Alouette II performs in Navy DASH tests. Above, the Kaman HU2K. Below, the HU2K (model) with jet pod mounted on side. Jet is GE J85, providing boost in speed, lift, range, and versatility.

ASW EQUIPMENT

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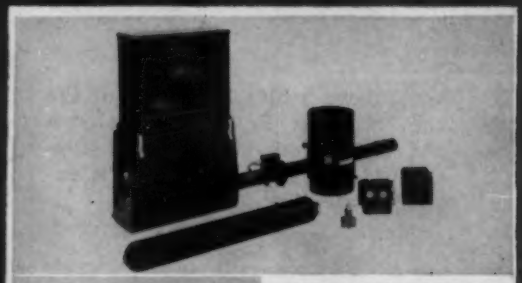
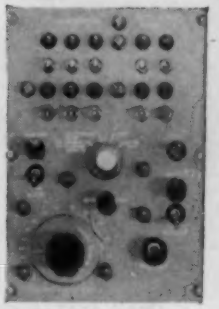
- Sonobuoy Launchers
- Retro Ejectors
- Actuators
- Control Panels
- Complete Systems

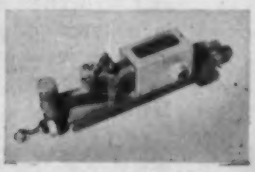


Retro Marine Marker Ejector System, Control Box, 3000 psi Compressor, Solenoid Valve, High Pressure Storage Bottle.

Sonobuoy ejector using "Pogo Stick" Free Piston Actuator principle.



Master Control Panel to control complete ASW stores ejection system.



Pneumatic Actuator for opening skin door.

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Associated equipment such as skin door actuators, compressors, valves and integrated control systems.

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Turbine-powered Sikorsky HSS-2 features a boat hull and twin GE T58 gas turbines. Shortly after ascent the HSS-2 retracts its wheels, and the boat hull enables it to serve as an amphibian.

by jet engines. Unmanned drones are coming into the picture. Suitable VTOL craft are being sought.

Strictly speaking, the Navy today uses only the Sikorsky HSS-1 (and the HSS-1N, with night configuration) in anti-sub work. But additional makes and types will be entering the fleet in the years ahead, including the Sikorsky HSS-2 powered by two gas turbine engines. The HSS-2 is expected in the fleet in 1961.

Versatility is the key to the helicopter's usefulness. The armed services use them for all sorts of utility jobs, search and rescue, reconnaissance, minesweeping, and missile recovery. Photography is difficult because of vibration.

In ASW work, helicopters bring new mobility to underwater detection gear. The HSS-1, for example

Workhouse utility helicopter of the U.S. Navy is Bell HUL-1, shown above. The four-place, 220-hp 'copter, used for utility purposes, is extremely flexible.

Bell HTL-6 serves as a basic training helicopter. It is equipped with skid or flotation landing gear, radio and hydraulic boost control, which is a form of power steering. This craft is well known to the Navy's helicopter men, and is similar to the HUL.

HELICOPTERS, U. S. NAVY AND MARINE CORPS

Model	Engine	Function
	OPERATIONAL	
Sikorsky H04S	C-W R1300-3	ASW
Sikorsky HSS-1 (Night config., HSS-1N)	C-W 1820-84	ASW
Vertol/Piasecki HUP	Continental R975-46	Utility
Sikorsky HUS-1	C-W 1820-84	Marine assault
Sikorsky HR2S	P&W R2800 (2)	Marine assault
Bell HTL	Lycoming VO-435	Trainer
Bell HUL	Lycoming VO-435	Utility
Kaman HOK	P&W R1340	Marine observation
Kaman HUK	P&W R1340	Utility
	IN PRODUCTION, UNDERGOING FINAL TESTING	
Sikorsky HSS-2	GE T58 (2)	ASW
Kaman HU2K	GE T58	Utility
	OPERATIONAL, EVALUATION COMPLETED	
Gyrodyne YRON-1	Porsche Y095-6, Solar T62	One-man rotorcycle
	OPERATIONAL, BEING USED IN DASH DEVELOPMENT	
Gyrodyne DSN-1	Porsche Y095-8	ASW
	OPERATIONAL, HAVE BEEN DEMONSTRATED	
Republic Alouette II	Artouste IIB-1	ASW
McDonnell 120	AiResearch GTC 135 (3)	ASW
Cessna CH-1C	Continental FSO 526A	All-weather utility
Sikorsky S-64 (Flying Crane)	P&W JFTD-12	ASW & utility
Hiller Camel (12-E)	Lycoming VO-540	ASW & utility
Vertol 107	GE T58 (2)	Utility

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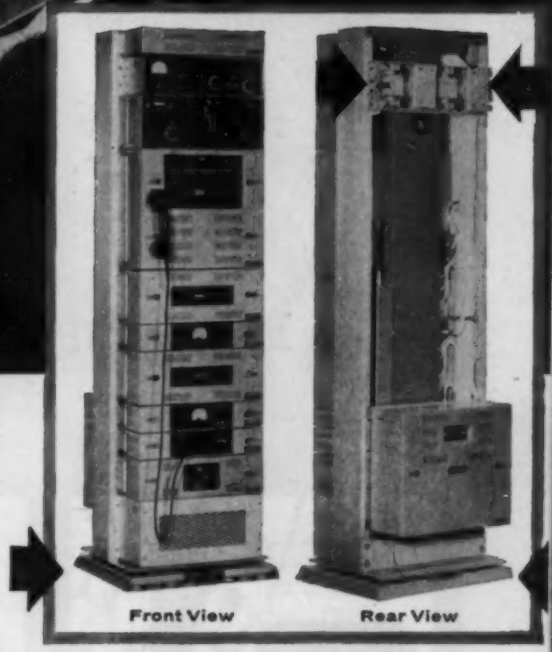

This is Robinson Model W664-3 with the Collins AN/URC-32 single sideband shipboard transceiver installed. This all-metal mounting system includes a heavy duty, dual stage base and a stabilizer unit which is mounted on the rear of the equipment.

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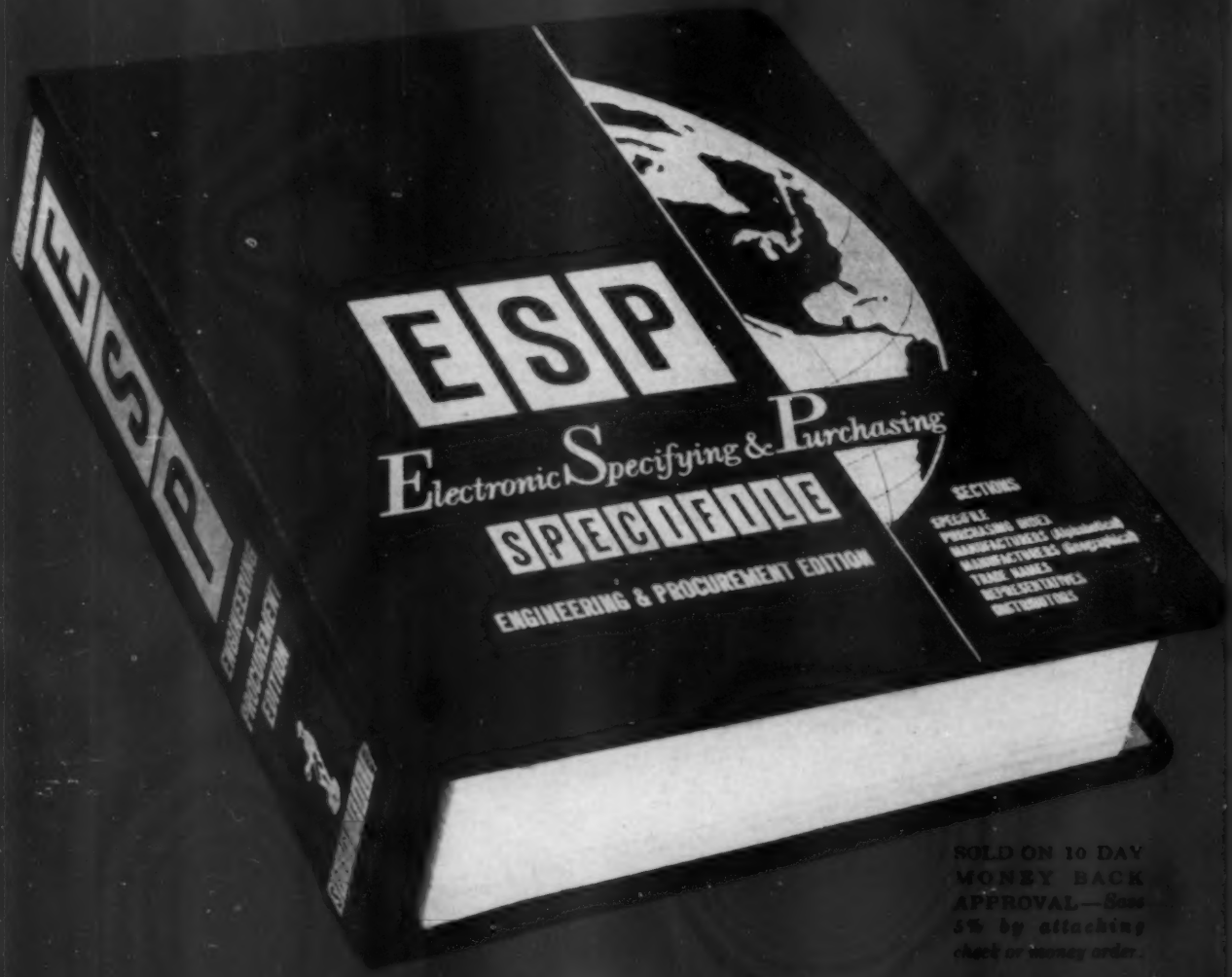

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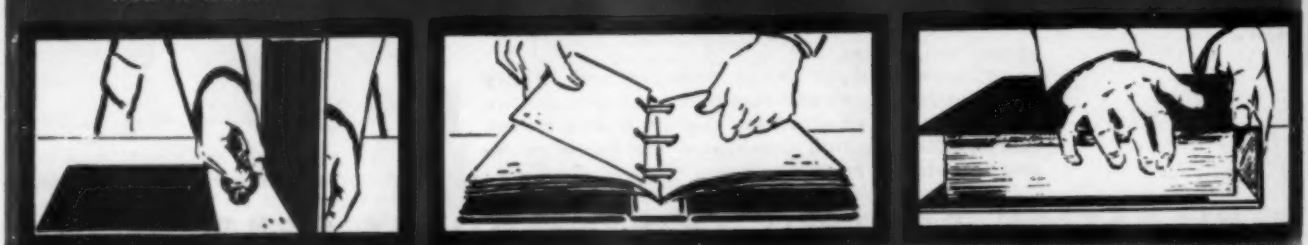

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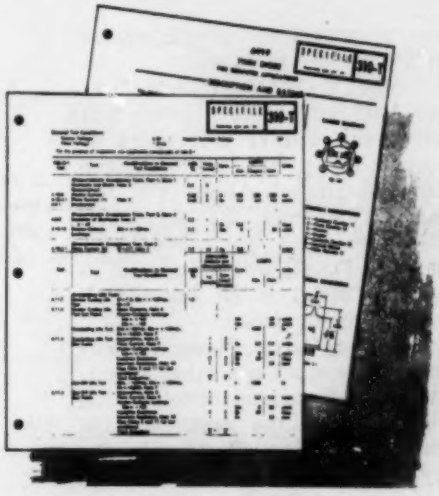

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Top left, sonar ball being lowered by Navy helicopter. Top right, Bell's HTL-7, the Navy's first integrated instrument helicopter trainer. It is powered by 260 hp Lycoming engine. Below, Gyrodyne's YRON-1 rotorcycle, for Marine Corps use. incorporates same basic coaxial rotor system and general design as drone DSN-1. Bottom left, the Sikorsky Skycrane, equipped with light minesweeping gear, which is carried in a pod beneath the airframe.

lowers a sonar ball into the water from a hovering position.

The Navy's DASH project (Destroyer-Anti-Submarine Helicopter) involves the use of destroyers as helicopter bases. DASH tests have included Republic's Alouette II, the Kaman HTK, and the Gyrodyne DSN-1. Gyrodyne was made manager of the DASH weapon system in 1959. Its DSN-1 is an unmanned, torpedo-carrying drone.

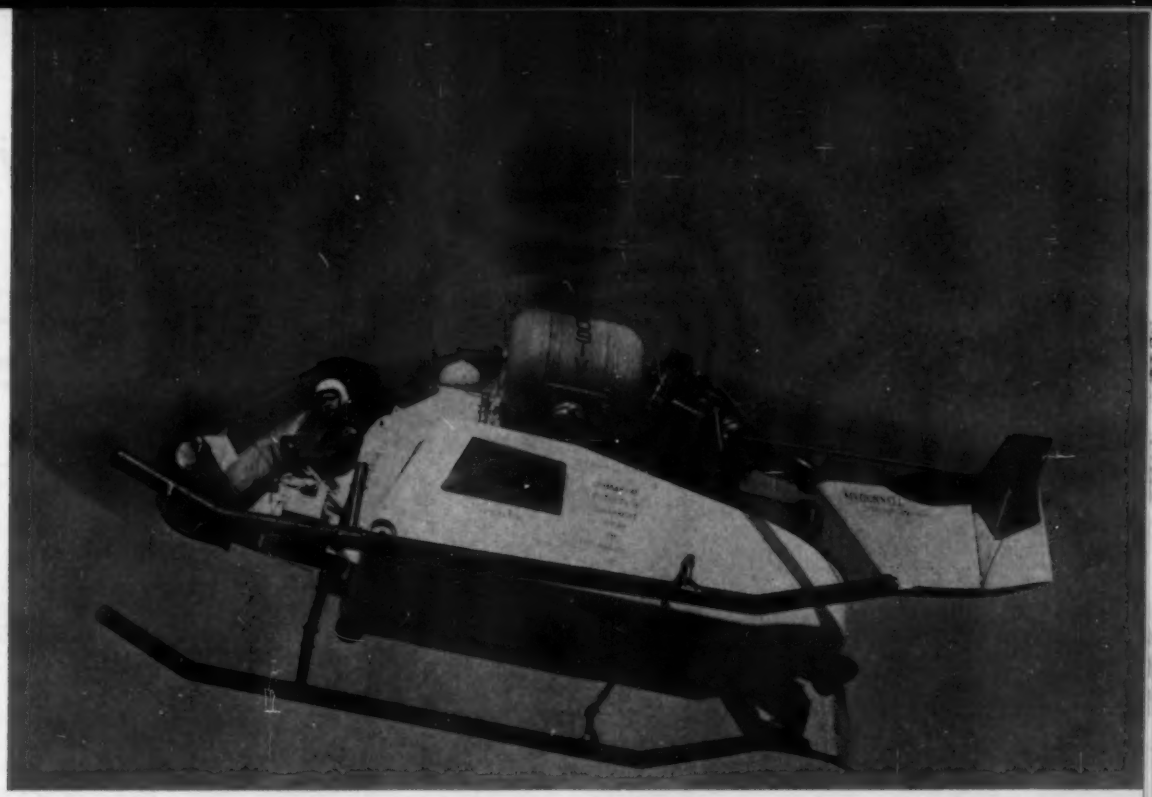
Bell, Hiller, Vertol, Piasecki, Cessna and McDonnell are other manufacturers with various models which have served in the past, or have present or suggested roles in the Navy, Marine Corps and Army. While some of them — the Kaman HU2K-1 for example — are not planned for ASW use, they do have ASW capability in that they can carry both detection and attack equipment.

The Navy also is looking into the feasibility of using VTOL craft in ASW, but so far considers it has not found one with an acceptable horsepower/weight ratio.

In ASW tactics, the doctrine of "sortie from the harbor" now includes the dispatch of helicopters to arrive first in the locality of the enemy subs. Navy helicopter people are naturally gratified at this, secure in their belief that in the job of tracking high-speed subs the helicopter has it all over everything else. "With sonar plus weapons, including those with homing devices as well as conventional types, helicopters put the offensive into ASW," they say.

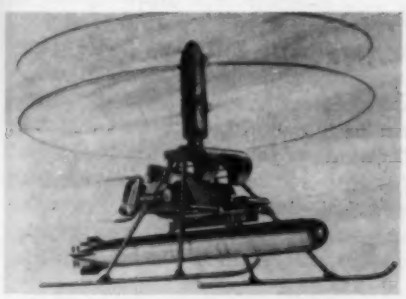
Development of the helicopter for ASW use generally dates back to 1946, when the Naval Research Lab built submarine sound equipment for installation in a Sikorsky XHOS. Tests proved its practicability. In 1950-51 highly successful tests were conducted at Key West, using a new sonar device in a Sikorsky HO4S-1. Today helicopters can be used for detection alone or for detection and destruction (hunter-killer) missions.

★ ★ ★



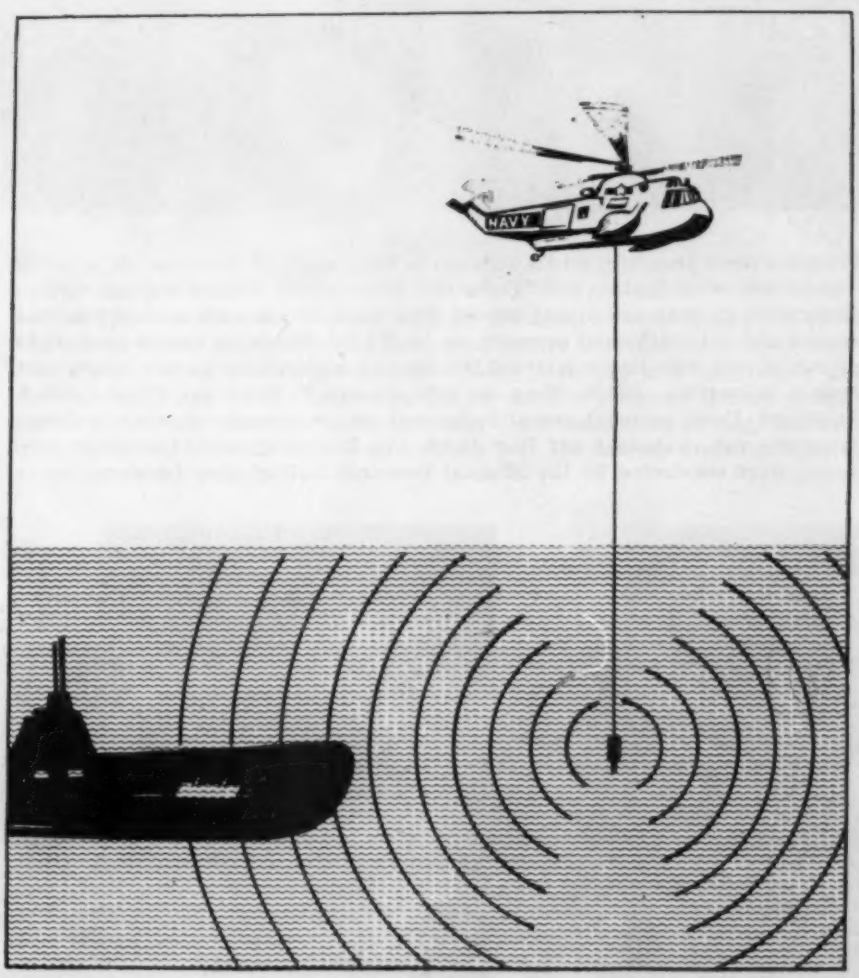
The McDonnell 120, a small, heavy lift 'copter powered by three AiResearch GTC-135 engines which supply compressed air to the blade tip-mounted hot-burning pressure jets. Has fast starting time of 35 to 40 seconds from initiation of engine start cycle to lift-off. Can serve as torpedo launcher, crane, ASW hunter-killer.

The Hiller 12-E, designed for ASW and utility purposes. Also used by Army.



Gyrodyne's remotely-controlled drone, DSN-1, used in DASH program.

Cessna CH-1C, designed for all-weather use, is stable in roll, pitch, yaw.



navy frogmen in ASW

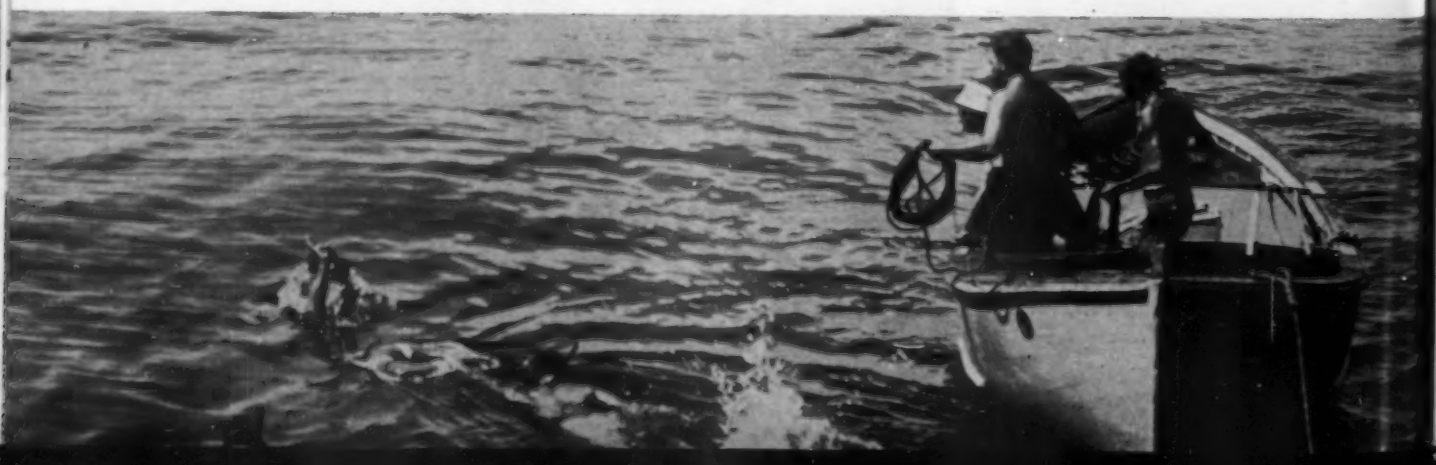
U. S. Navy frogmen too often are thought of as mere skin divers who place demolition charges in shallow water in advance of a combat landing.

Actually today's frogmen can play important ASW roles and also assist in the important oceanographic research associated with successful ASW methods.

Human beings operating underwater obviously require very special equipment. SCUBA equipment is part of this. SCUBA stands for "Self Contained Underwater Breathing Apparatus." New types were being tested by frogmen in the arctic pictures shown on these pages.

It is also essential for frogmen to be equipped with accurate watches. In view of the undersea water pressures encountered by frogmen, these watches are known as the "toughest" in the world. Bulova Watch Co., Inc., developed them for the Navy for split-second accuracy under terrific pressure. The watches also serve as aids to navigation in gloomy waters where there are no familiar

Frogmen need accurate, tough watches to keep track of precious air supplies and for use as navigation aids. These two divers check Bulova watches undergoing tests in deep-sea diving school. The watches have an accuracy to one second and can withstand pressure up to 175 psi. Below, a rescue boat picks up two divers who just completed the deepest underwater escape ever made from a submarine—302 ft. They are Cdr. George F. Bond and Chief Cyril J. Tuckfield. Using buoyant ascent individual escape procedures, they surfaced from the sub *Archerfish* off Key West, Fla. The tests, called Operation Subscape, were conducted by the Medical Research Lab of New London.



landmarks. They are made of non-magnetic materials.

Another function of Navy frogmen is to test underwater escape procedures. This was the purpose of "Operation Subscape" conducted off Key West, Fla., recently by the Medical Research Laboratory, Naval Submarine Base, New London, Conn.

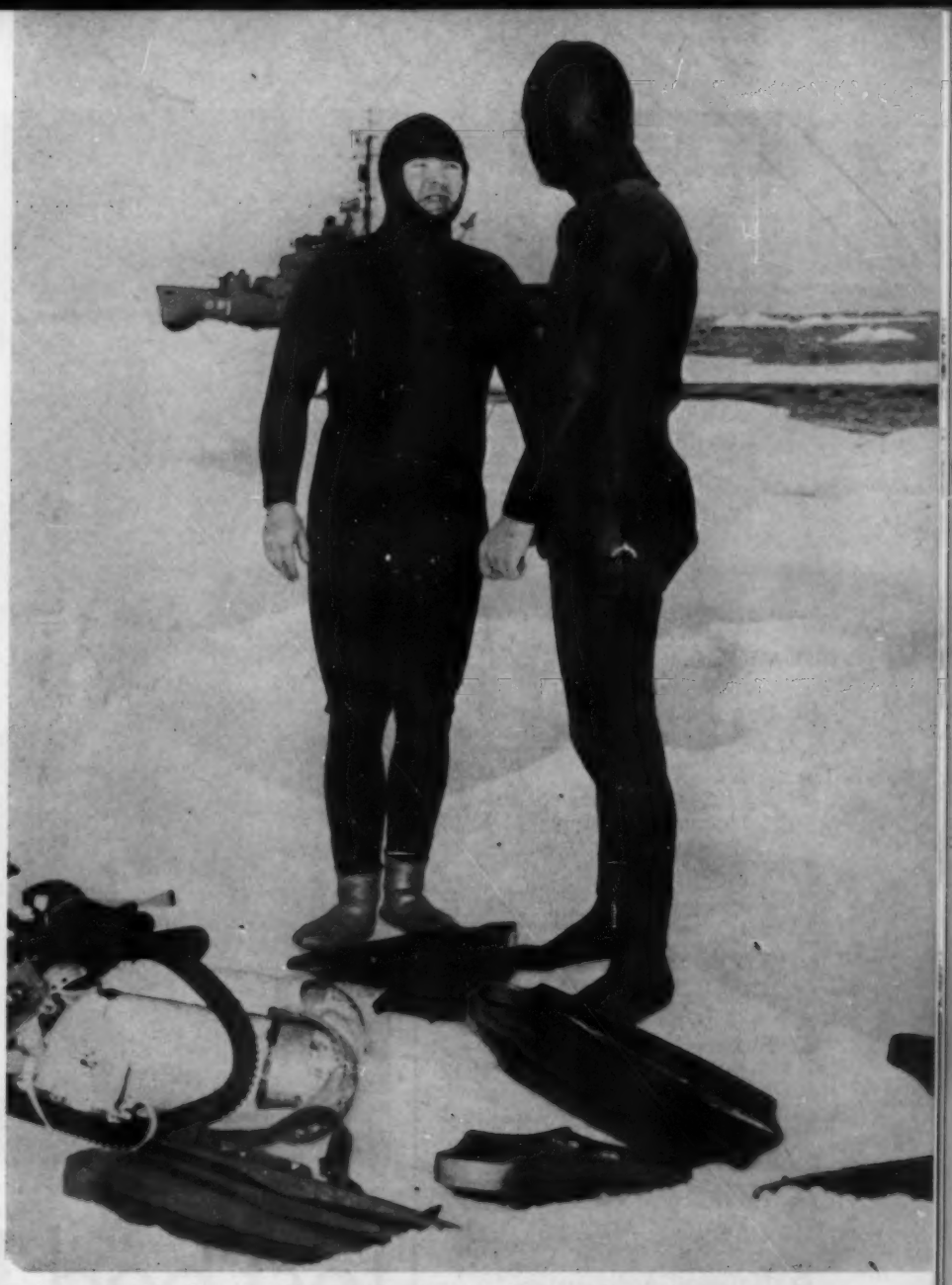
One of those who made the deepest underwater escape from a submarine was the officer-in-charge of the Medical Lab, Cdr. George F. Bond (MC), USN. His companies in the dramatic escape was Cyril J. Tuckfield, ENC (SS), USN, attached to the submarine *Seacat*.

Tests and evaluations which are an important part of the routine at the Key West Naval Base are giving more and more emphasis to ASW.

Many Naval officers are coming to regard the development of ASW as of importance to the Navy's future, and in this connection are anxious that oceanographic research be stepped up and that facts obtained be transmitted to commanders at once for application at sea.

The Russian submarine threat makes ASW and its twin, oceanographic research, more and more important in the naval scheme of things.

ASW represents one of the free world's greatest hopes for successful deterrent power.



Extremes in weather conditions present no problems to Navy frogmen. Above, two of them prepare to dive into icy arctic water, with the Navy Icebreaker *USS Burton Island* in the background. Below left, the pair who made the underwater escape from a sub relax aboard the *USS Penguin*. Center picture shows the "clock watchers" synchronizing their timepieces. Right, the two SCUBA divers from the *Burton Island* return to the surface after 30 minutes under the arctic ice pack.

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test bed for polaris

By Commodore A. D. Hunter (CEC USN Ret.)

Missile support activities have put civil engineers and construction contractors into some odd places—but probably none has been so odd as a point in the open ocean, some 60 miles off the coast of California.

Here, off the shore of tiny, bleak San Clemente Island, Navy missilemen handed out this job:

In very deep water, build a circular concrete launching pad about 10 ft thick, and 30 ft in diameter, embedded in the ocean bottom, to contain more than 235 cubic yards of concrete (about 500 tons), and to be equipped with various mountings and accessories. And, do this job in exactly 23 days of construction time, after less than two months of surveys and design, despite the danger of fog, high winds and "Santa Ana" conditions (where winds shift radically, and within a few hours can kick up a hurricane-sized storm).

The reason: This was the site selected for testing prototypes of the Navy's solid-fueled POLARIS missile. It had to be completed in time to coincide with production of the prototypes and testing apparatus, and approximate as nearly as possible actual conditions the missile would

encounter when fired from a submarine.

It can now be revealed that the job was done in the time allowed. The work was actually completed in the Fall of 1957, but has remained under security wraps until now. It took the cooperation of the Navy's Bureau of Yards and Docks; a private consulting engineer firm; a four-contractor construction combine; divers; a closed-circuit television hookup; clever construction techniques—and a lot of luck.

• *Design starts*—San Clemente Island—a Naval testing station which is distinguished principally by a cluster of a half-dozen trees known to personnel as the "San Clemente National Forest"—had certain advantages for what the Navy had in mind for its POLARIS tests. There is little rainfall, the weather is generally good (except for the aforementioned "Santa Ana" conditions), and security is an easy problem.

As officer-in-charge of the project for the Navy Civil Engineers Corps, I was much concerned that the design we finally settled on would be a feasible one, in spite of the possibilities of interruption by weather. To insure that we obtained the best possible thinking on the problem—both from the theoretical and the practical sides—we did something unusual in ordinary construction practice: We brought the engineer and the contractor into the picture simultaneously, and from the very beginning.

Thus we had the advantage of the engineering knowledge of the Newark, N.J. consulting firm of Porter, Urquhart, McCreary and O'Brien; the practical know-how of a four-contractor combine known as CHAD-JV (Cox Brothers, Haddock Engineers, The Arundel Corp., and L. E. Dixon Co.); plus the experience and knowledge of the Bureau of Yards and Docks itself.

With this team working smoothly from its inception, the scedule went this way:

On October 1, 1957, a month of field work—consisting of oceanographic studies and hydrographic surveys—was completed, and the exact site was selected.

On October 4, 1957, detailed design was started.

On October 15, 1957, the contractor was given notice to proceed.

On November 18, 1957, final design was completed.

On November 23, 1957, 57 tons of steel foundation forms, base ring and levelling frame had been completed on the island.

On November 26, 1957, actual construction at the open-sea site began.

On December 19, 1957, underwater construction was completed.

In March, 1958, Navy missilemen fired—successfully—the first POLARIS prototype.

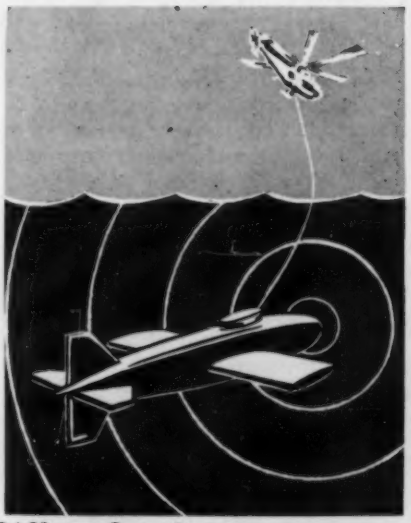
• *How it was done*—The foundation form was actually an open, circular steel box, with relatively sharp cutting edges on its bottom side. It would be barged out to the site from the mainland 60 miles away, lowered until its cutting edges rested on the bottom, then sunk into the sand to a depth of 10 ft, by use of jets of water and air, previously placed along the cutting edge, to displace the bottom sand. The material displaced in this manner was to be raised to the surface for disposal by what construction men call an "airlift"—pushed up through pipes by air pressure.

The same "airlift" method was then planned for use to complete excavation of the area within the big steel form, clearing the way for placement of concrete poured through pipes. Divers—aided by surface operators who would view the scene through a closed-circuit television hookup—would direct the underwater operations.

• *And so to work*—With all the planning done, the steel forms were loaded on a crane-equipped barge, and on November 26 all was in readiness for a start. As could almost be predicted, our worst fears were immediately realized: A "Santa Ana" blew up a storm that carried wind gusts up to 75 miles an hour. But we were in luck, anyway. By the next day, the winds had subsided and the barge was towed safely to the site, and made fast to a derrick barge. There was a further — fortunately temporary—delay, when fog obstructed the line of sight of positioning transits located ashore (the pad had to be placed with considerable accuracy because of testing requirements).

Divers were sent down, and four positioning points—steel pipes—were set in the ocean bottom so that the divers could align the form visually as it was lowered. They used, in addition, an improvised "plumb bob," consisting of a heavy, pointed steel weight, suspended by a piano wire from the floating crane.

With the big form seated, another problem came up. As mentioned, it had been intended to sink the form by a combination of jets and airlift excavation. But we were worried that the jets might blow the sand out from under the form unevenly, so



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that our final platform would not be level.

To solve this, it was decided to use the airlift only—and that had to be modified. The 14-inch pipe used to suck up the sand created such tremendous suction that the divers could not get close enough to it to guide it near the cutting edges of the form. A 6-inch pipe finally was built so that the divers could handle it, and a bundle of old steel rails was added to the weight of the form for better pressure. With this arrangement, the form was sunk to proper location and level in a day and a half.

This done, the launcher base ring and the triangular levelling frame were lowered and secured to the form. That is a simple statement—but it was no simple operation. At each corner, the levelling frame had two legs on wheels, enabling it to ride on top of the form and be rotated to the prescribed position, horizontally. Then vertical adjustment was made by 20-ton jacks installed between each point of the levelling-frame triangle and the top of the form.

Working under the pressure of more than a hundred feet of ocean water, the divers made the last adjustments to bring the ring to its final position, in a complex maneuver that was checked from the shore by the use of transits and the plumb-bob mentioned previously. A special problem was that the water depth was so great that divers could work only 50 minutes at a time—and could make only one such dive in 24 hours.

• *Concrete goes in*—Next came the final step—placing of concrete. Plans called for placing the aggregate (stone and gravel) in the form immediately after setting the base ring. Cement was then added, in a water solution, by pressure pumping from the surface. Rough seas delayed arrival of the aggregate barge, and a precious half-day of time was lost. It was not possible to observe the aggregate placing directly, since the placing of the tons of material so muddied the water that the divers could not see. But—despite our anxiety—a check afterward revealed that the contractor's skillful handling had not disturbed the positioning of the steel work.

Concrete was formed in two stages —the first being a three-foot depth that would form a seal, the second being the remaining 10 ft (approx.) needed to complete the job. Thus, a first pour of 77 cubic yards was made and allowed to harden overnight, before the final pour was completed.

After three months of continuous effort by all concerned, the underwater portion of the unprecedented "POP-UP" project went from conception to finish. In the succeeding weeks, the attendant supporting features of roads, communications, cameras, missile fall-back net, etc., were installed, and we were ready for the first tests.

• *Credits*—In addition to the consultants and the contracting firms themselves, three other men deserve special mention for their work on this project. They are: Victor Hertzlet of the Arundel organization and Les Miller of Cox Brothers, who were "lent" to the advisory team at the beginning, and stayed with the job to its completion—many of the features of the design were the result of their suggestions; and Lt. Cmdr. Robert E. Dickman, then of the Navy District Public Works Office, Eleventh Naval District, San Diego, who served as Resident Officer in Charge of Construction for the duration of the work.★

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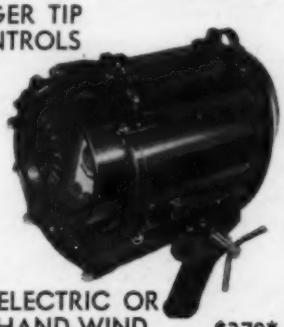

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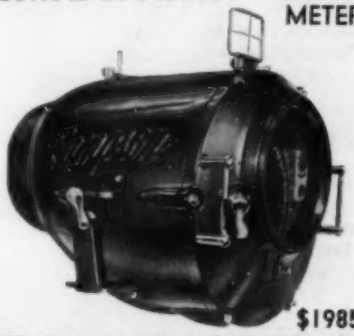

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new vp's at raytheon

Raytheon Co. has elected three new vice-presidents, two of them holders of U.S. Navy awards. They are **Glenn R. Lord,** general manager of Equipment Div.; **Fritz A. Gross,** assistant general manager of Equipment Div.; and **Thomas L. Phillips,** assistant general manager of Missile Systems Div. **Mr. Lord** joined Raytheon in 1958, serving as manager of Airborne Equipment Operations until appointment as Div general manager in 1959. He formerly was director of Bell Aircraft Corp.'s Space Flight and Missiles Division. **Mr. Gross,** radar expert, is a 26-year veteran with Raytheon. For his accomplishments in microwave search radar and fire control radar, he was awarded the Navy's Certificate of Merit Commendation. **Mr. Phillips** joined Raytheon in 1948. Outstanding work on the Navy's SPARROW III missile system, for which Raytheon is prime contractor, won him the Navy Meritorious Public Service Citation.

sperry man on *triton*

Eldon E. Good, Sperry Gyroscope Co. civilian specialist on submarine inertial navigation systems, made the epochal round-the-world trip on the nuclear submarine *Triton.* The 23-year-old field engineer joined Sperry in February 1959 after mid-year graduation from the University of Kansas. Since the beginning he has been specializing on the Sperry Ship's Inertial Navigation System.

vaeth to reflectone

Appointment of **J. Gordon Vaeth** as manager of its newly-opened Washington office has been announced by Reflectone Electronics, Inc. **Mr. Vaeth,** formerly a member of the Institute for Defense Analyses and specialist on manned space flight, will assist the company with its activity in advanced space systems and technologies.

johnson elevated

Dr. Ralph P. Johnson has been appointed vice president, Electronics Divs., Thompson Ramo Wooldridge, Inc. He will be responsible for activities within TRW's five electronics divs.: Commercial Electronics Group, Electronic Components Group, Pacific Semiconductors, Inc., Ramo-Wooldridge Div., and the Thompson-Ramo-Wooldridge Products Co. **Dr. Thompson** was formerly TRW vice president and general manager of Ramo-Wooldridge Div.

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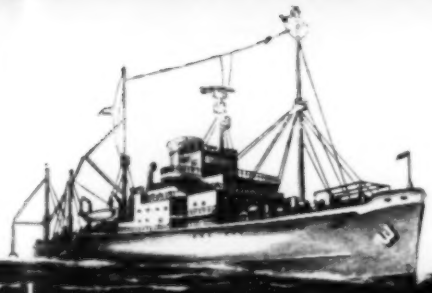

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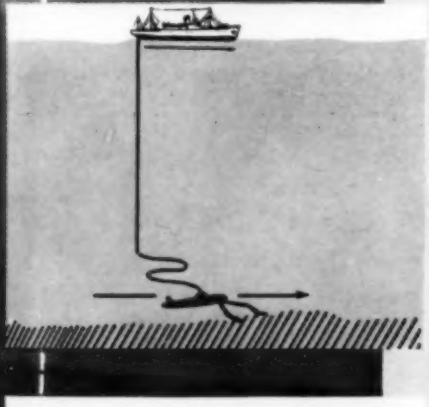

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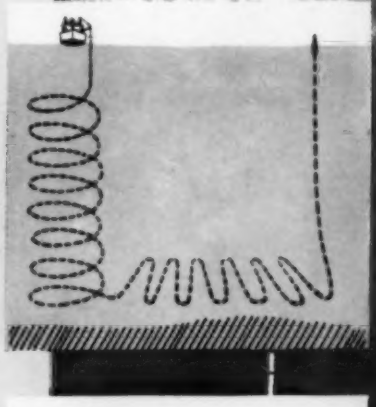

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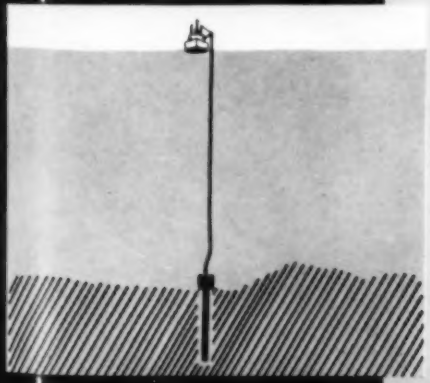

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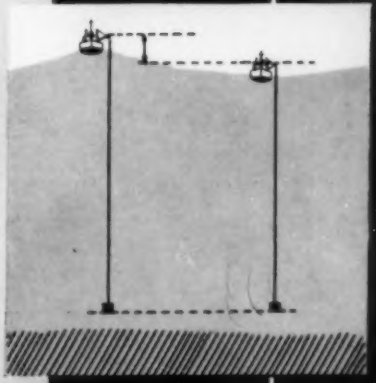

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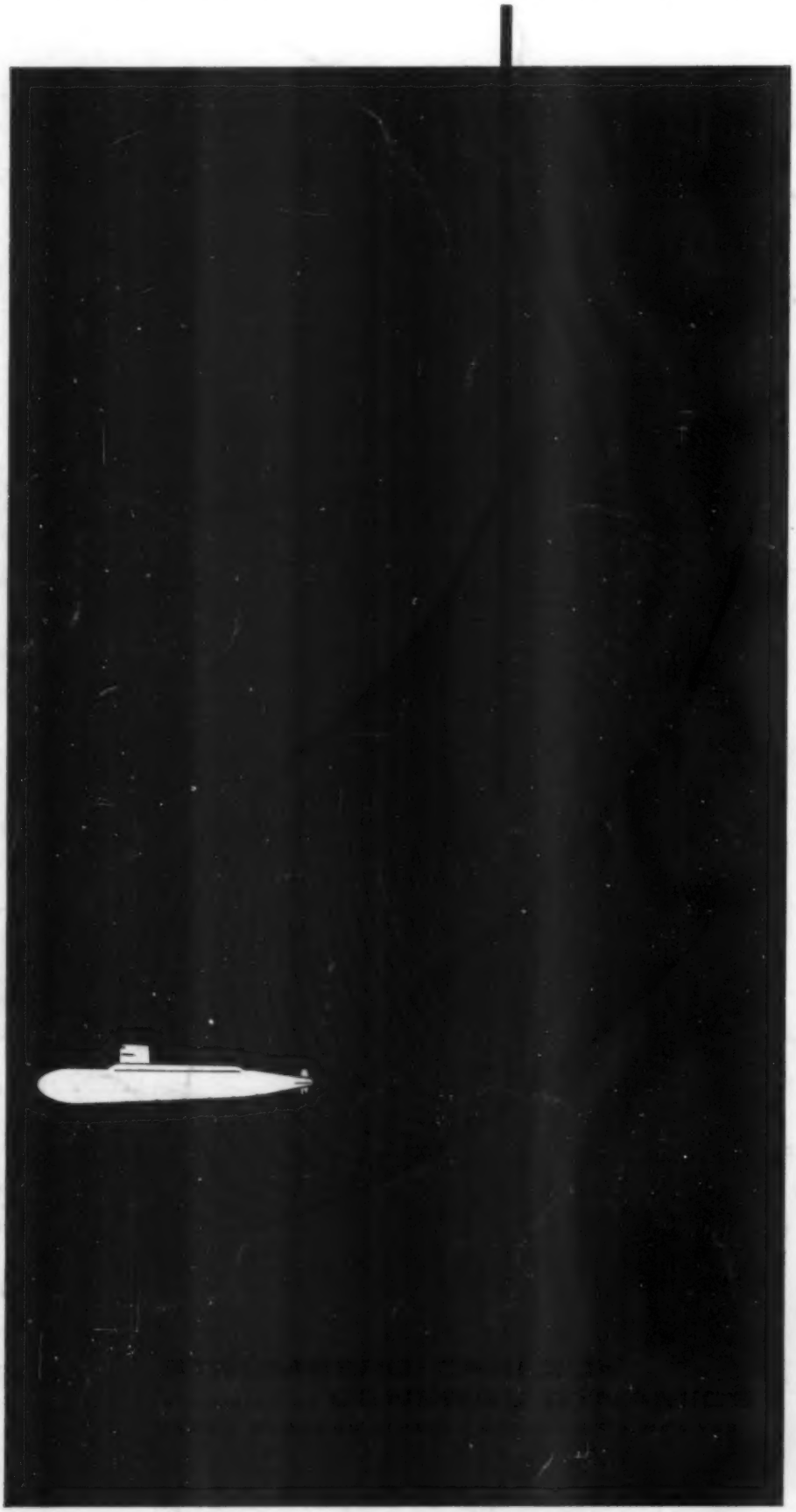

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. . . an area of critical interest
to Stromberg-Carlson.

Quiet, swift and deep-running, nuclear-powered submarines demand new performance from undersea warfare devices.

Equipment is urgently needed for improved underwater detection, classification and localization.

Stromberg-Carlson research programs will result in new undersea warfare electronic systems.

Unequalled tank-test facilities and automatic test instrumentation enable Stromberg-Carlson to conduct the exhaustive tests required to develop the complex ASW equipment of the future.

Brochure on request.

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